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THE BLOOD-SUCKING MITES OF THE GENUS *HAEMOLAELAPS* (ACARINA: LAELAPTIDAE) IN THE UNITED STATES

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INTRODUCTION

In recent years the U. S. Public Health Service has shown a renewed interest in both murine tpyhus and sylvatic plague and this interest has resulted in the trapping and combing for ectoparasites of large numbers of small wild mammals, chiefly rodents. In these recent surveys more attention has been paid to mites than in previous surveys and this has served to emphasize our need for adequate information and descriptions of these ectoparasites, many forms of which are still undescribed. Of those that are described, most are poorly or not at all illustrated, and often the descriptions are so ambiguous as to be worthless or even out and out misinforming. There have been recent attempts, and with a certain measure of success, to remedy this barren situation. One of these is the Mite Atlas prepared by the U. S. Public Health Service under the supervision of Dr. Pratt (1947). Unfortunately, many of the drawings for this atlas were made by a professional artist not too well conversant with the intimate details of mites, and the result is drawings of pleasing appearance that undoubtedly serve a useful purpose, but that are lacking in detail and contain minor errors that make them useless for critical study.

Grant's (1947) paper on North American *Laelaps* is very good but is not as comprehensive as the title indicates. The most unfortunate circumstance is the complete omission of *Laelaps nuttalli* Hirst (= *L. hawaiiensis* Ewing) as this is one of the most common mites on rats in southern and eastern coastal United States. An obvious error was made in showing five setae on the anal plate of *L. echidninus* Berlese. It has only three as do all other species of *Laelaps*. Also the coxa I (of *echidninus*) has not two heavy spines as shown but one spine and one slender seta. A typographical error appears on page 2 (of Grant's paper). The date of Ewing's Manual, in which the genera *Eubrachylaelaps, Geneiadolaelaps, Macrolaelaps,* and *Echinolaelaps* were erected, is 1929, not 1922.

It is the hope of the present writer that he may have profited somewhat by the precedent work of his colleagues and that the following discourse on the North American *Haemolaelaps* will contain a minimum of errors.

ACKNOWLEDGMENTS

A great many individuals have contributed specimens and criticisms and my thanks go out to all of them, but I want especially to mention: E. W. Baker who

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assembled over 900 slides in the U. S. National Museum and made them available to me and who extended courtesies to me during my visit to the museum in the summer of 1946; Dr. H.E. Ewing for placing type slides at my disposal, for his graciousness and courtesy, and for his gift of representative specimens; H. B. Morlan for the very large amount of fresh material from south Georgia; D. C. Thurman for material from Florida; George Menzies, R. B. Eads, and Neal M. Randolph of the Texas State Health Department for material and criticisms; Dr. Earl A. Pritchard for criticisms and encouragement; Olin E. Hunt of Houston for specimens and pertinent suggestions and especially for his generous loans of literature; and Mrs. R. W. Strandtmann for her perspicacity and perseverance in preparing the statistical analyses of measurements even though she had plenty else to do and could see no earthly reason for it anyway!

METHODS AND MATERIALS

For the preparation of this paper the author has examined some 2500 slides for a total of about 5000 mites. This represents material from a great many hosts and from all parts of the United States and southern Canada. Mexican material is almost entirely lacking.

The measurement units in this paper, and the symbols for them are given below:

TL —Total length, exclusive of the gnathosoma.
TW —Total width of body at widest point.
DL —Length of dorsal plate.
DW —Width of dorsal plate.
SL —Length of sternal plate at mid-ventral line.
SW_1—Width of sternal plate at narrowest point.
SW_2—Width of sternal plate at widest point.
GVL —Length of genitoventral plate, measured from base of sternal plate to tip of genitoventral plate.
GVW —Width of genitoventral plate at widest point.
AL —Length of anal plate, measured from anterior border of the plate to the base of the odd seta.
AW —Width of the anal plate at widest point.
GV–A —Distance from the posterior tip of the genitoventral plate to the anterior border of the anal plate.
LF —Length of Leg I from base of coxa to tip of tarsus (exclusive of the ambulacral apparatus).
LH —Length of Leg IV.
FTL —Length of tarsus I (exclusive of the ambulacral apparatus).
FTW —Width of tarsus I at about the middle.

I believe that a set of measurements could be a very important adjunct for proper definition of species if all specimens were mounted in the same way and in the same medium and if the host were always properly identified. As a rule, specimens mounted in xylol soluble media are somwhat shrunken and distorted, rarely are they fully extended. On the other hand, old mounts of polyvinyl alcohol are excessively flattened and thus give a distorted measurement. Also the specimen, or at least the part to be measured, must be in the same plane from end to end.

The gnathosoma which is discussed in detail on page 334, has several important generic and some very important specific characters. Admittedly these are sometimes difficult to find, but in the proper mounting medium they can be seen. Speci-

mens mounted in a hydrophilic medium such as polyvinyl alcohol or any of the various chloral hydrate media and not stained, show the gnathosomal structures quite satisfactorily. Specimens which are dehydrated through the alcohol series and mounted in xylol soluble agents never satisfactorily show the finer structures, whether stained or not. Some structures of the gnathosoma can be much better studied if the gnathosoma is removed from the body of the mite and mounted on its side. This is very easily done with the aid of a couple of minuten Nadeln by holding the mite with one needle and squeezing off the gnathosoma with the other. The mouth parts are so shaped that nine times out of ten they end up on their side under the cover slip without any extra manipulation. The epistome especially shows up much better in side view. (See Figs. 19 and 20).

The formula I prefer is the modification of Berlese's chloral-gum solution as given by King, Bradley and McNeel (1942) for mosquito larvae, as follows:

Gum acacia (clear lumps)	grams	8
Distilled water	milliliters	8
Glycerin	milliliters	5
Chloral hydrate	grams	70
Glacial acetic acid	milliliters	3

The gum acacia should be completely dissolved in the distilled water before the other ingredients are added in order. This is a slow process and may take as many as 48 hours. The thick solution is strained through clean muslin before use.

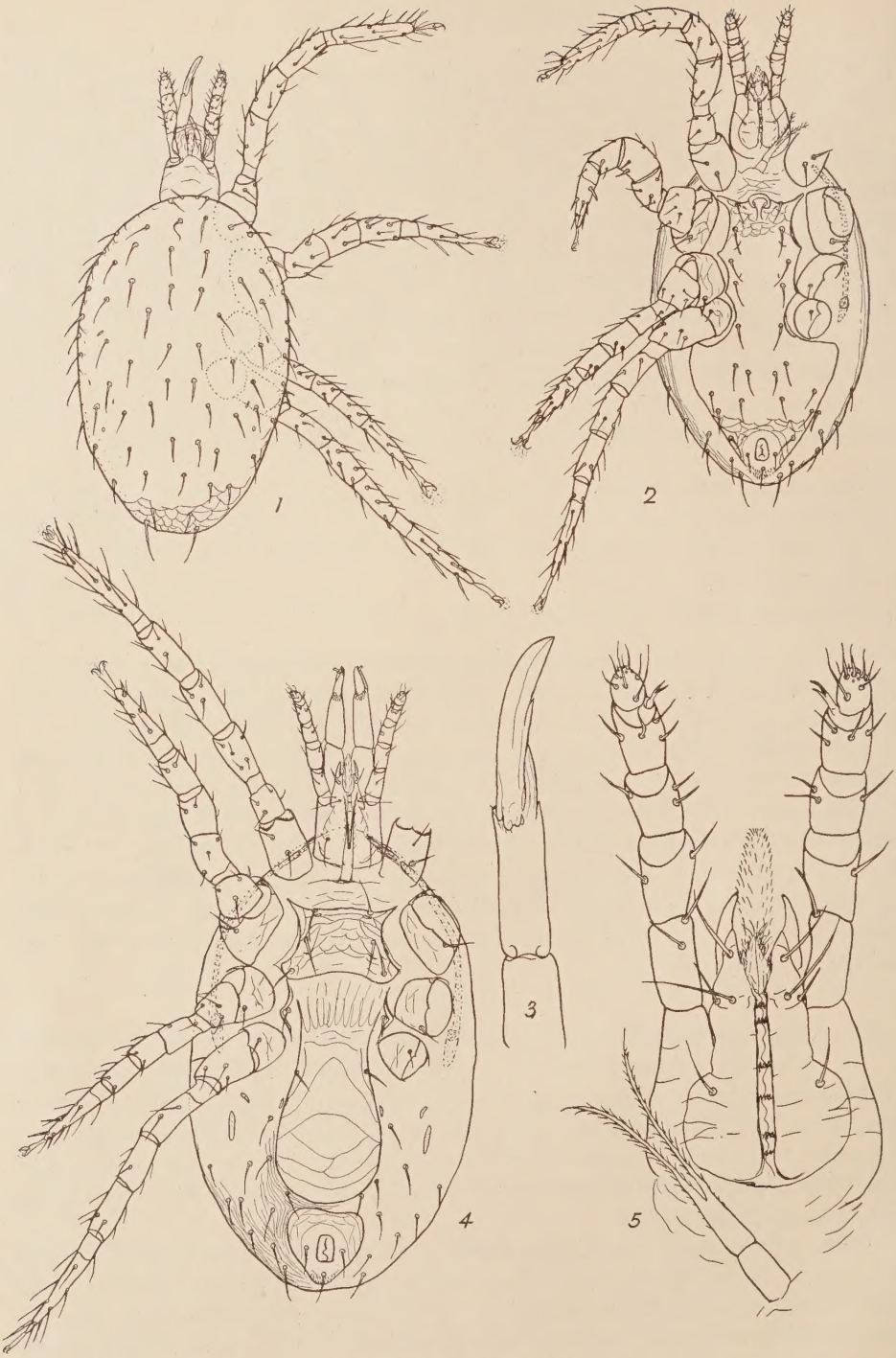
Live, freshly killed, or preserved specimens may be mounted directly into this medium. I have found it desirable never to use KOH, lactic acid or any other clearing agent. The slides are placed in an oven at 36° to 40° C. and dried for a period varying from three days to three weeks. Apparently they may be left in the oven indefinitely. In a climate as humid as Galveston's it is necessary to seal the cover slip, no matter how thoroughly the slide has been dried. I use a fairly viscous solution of Clarite for this purpose but other substances are probably just as good, or perhaps better.

ECOLOGY

From the collection I have seen it appears that mites of the genus *Haemolaelaps* have a preference for the RODENTIA. I have records however from many other small mammals, including marsupials and carnivores, and it may well be that if these latter hosts were as assiduously examined for parasites as rodents generally are, one would find them to be just as commonly infested. They are also taken from birds with enough regularity to suggest that they may be more than just chance associates of avians.

There are also many records from border and coastal quarantine stations showing these mites to have been recovered from various non-animal sources, such as packing material, bulbs, vegetables, fruits, etc. But this can be explained by an assumption of earlier rat or other rodent proximity and need not imply that they are non-parasitic varieties.

Although this genus of mites is frequently found in large numbers on certain wild rodents, it has never been tested for disease carrying propensities. It is of course extremely doubtful that it would ever prove of direct significance to human



EXPLANATION OF PLATE I

Haemolaelaps megaventralis

FIG. 1. Dorsal view of male.
FIG. 2. Ventral view of male.
FIG. 3. Chela of male.
FIG. 4. Ventral view of female.
FIG. 5. Ventral view of gnathosoma of male.

health but it may well be an agent in perpetuatng a sylvatic reservoir which in time might flare up and become a human health menace.

For the reasons given later under the discussion of the larva, I believe these species are ovoviviparous and give birth to the first nymphal form. Apparently an egg matures and develops to its final stages before a second begins, as I have never seen more than one egg (or larva, or nymph) in a female. However, the period of development is quite short. If some 20 to 30 females are placed on a clean host, they will build up a very sizable colony in a month.

As in most parasitic mites, the form most abundantly found on the host is the female. On heavily infested animals one will find also the males and both nymphal forms but these are found more commonly in the nest. The male probably does not feed on the blood of the host but the presence of blood may be demonstrated in both the proto- and the deutonymph. Since they are so seldom found on the host they evidently leave immediately after feeding and moult in the nest.

Host specificity does not seem very marked in this group except that apparently *Haemolaelaps geomys* is limited to the GEOMYINAE. *H. morlani* so far has been found only on *Rattus* species but too few records are available. The remaining two species seem to exhibit very little host preference although *H. megaventralis* seems to be more frequently associated with birds and tree squirrels. There is some indication that *H. glasgowi* varies slightly according to the host from which it is taken. No constant morphological differences could be demonstrated but a large series of measurements taken according to host and analyzed statistically gave some rather interesting results. This is discussed more fully under *H. glasgowi.*

The records available for this study indicate that the mites may be recovered during any season that the host can be captured. It would be useless to try to draw any conclusion on seasonal incidence from anything except a planned, year around collection project. Such a program has been under way for two years now in south Georgia under the direction of Harvey B. Morlan. When the results of this work are published, we should know much more about seasonal incidence of *Haemolaelaps.*

The Genus *HAEMOLAELAPS* Berlese, 1910

1910 *Haemolaelaps* Berlese, p. 261

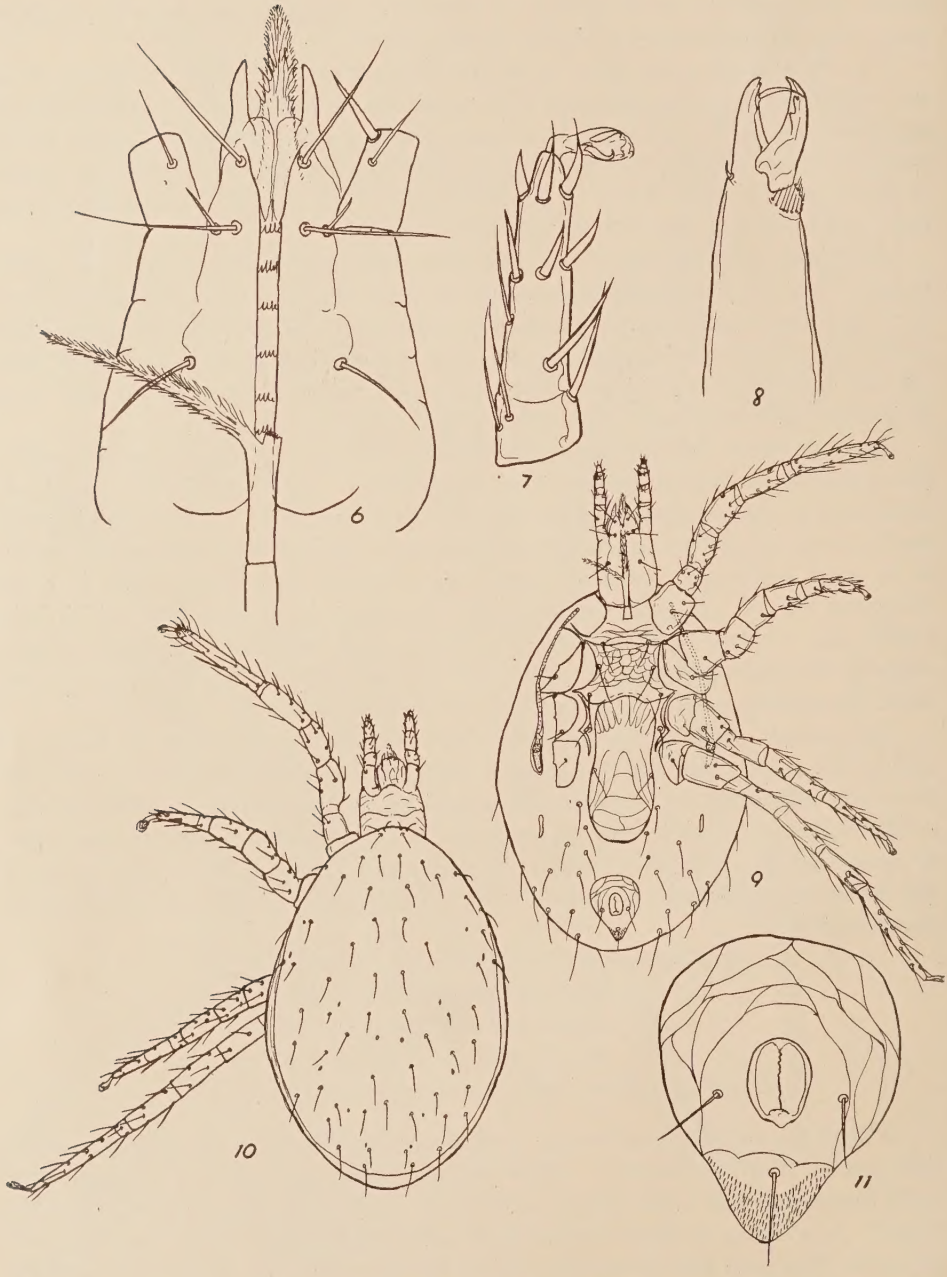
1929 *Atricholaelaps* Ewing, p. 186

1935–36 *Ischnolaelaps* Fonseca, p. 19

Genotype: *Haemolaelaps marsupialis* Berlese, 1910.

Berlese created *Haemolaelaps* as a subgenus of *Laelaps* for the reception of the new species *L. H. marsupialis.* Both the subgeneric and specific diagnoses were quite inadequate and a satisfactory description or illustration has never been published. The status of *Haemolaelaps* is therefore still doubtful but it has been accepted by European and British acarologists for mites of a structure similar to those with which this monograph deals and for this reason we have chosen to adopt it.

Vitzthum (1927) discussed this matter when he gave his reasons for placing *Haemolaelaps omnitectus* in Berlese's genus. He writes that when Hirst (1915) described *Laelaps* (*Haemolaelaps*) *nuttalli,* Berlese stated that this was incorrect, that *L. nuttalli* was a *Laelaps sensu strictu* and did not correctly represent his subgenus *Haemolaelaps.* But when Hirst later (1916) described another form, (?)



EXPLANATION OF PLATE II

Haemolaelaps morlani n. sp.

FIG. 6. Ventral view of gnathosoma.
FIG. 7. Ventral view of tarsus II.
FIG. 8. Chela.
FIG. 9. Ventral view.
FIG. 10. Dorsal view.
FIG. 11. Anal Plate.

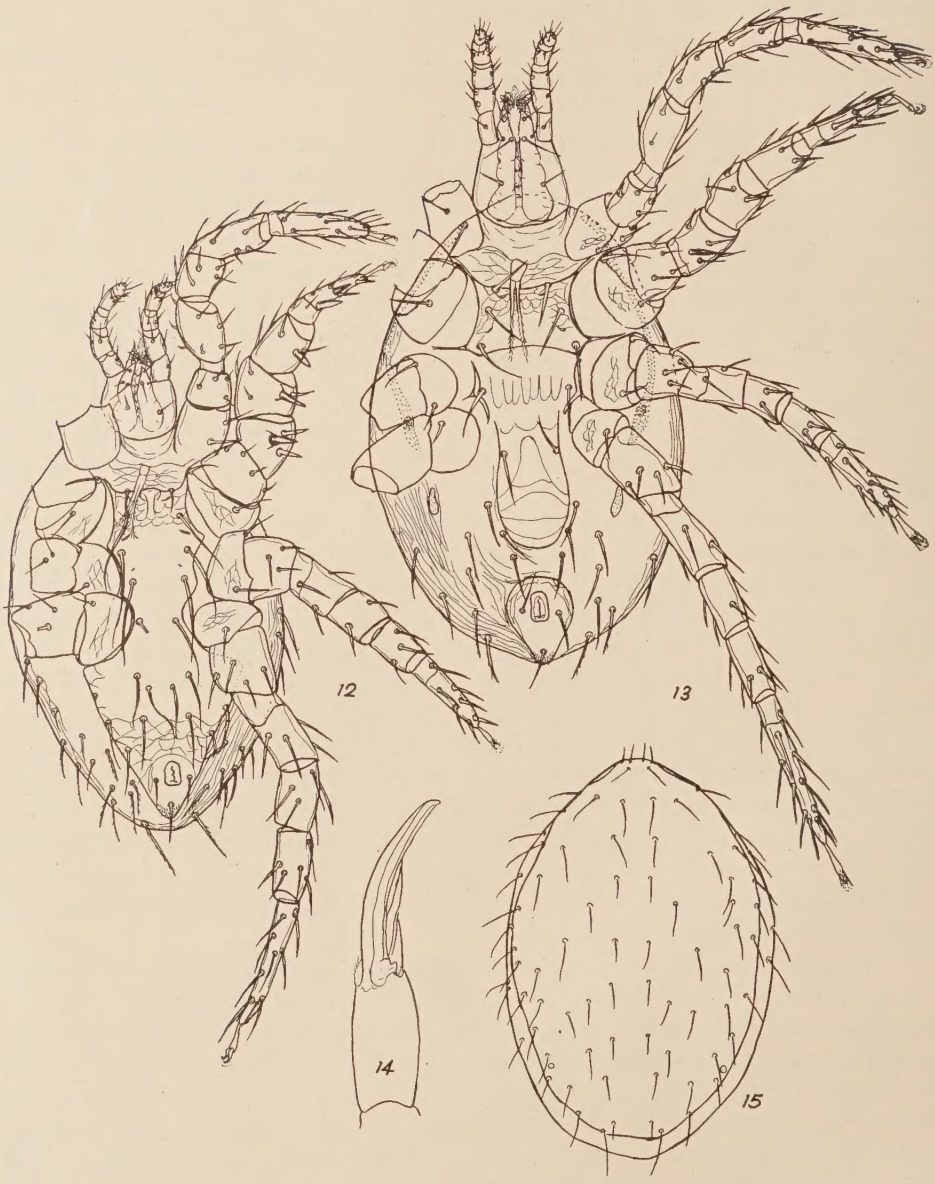
Haemolaelaps capensis (which is very similar to the forms here considered) Berlese made no comment though he could just as well have done so a second time. This indicates that it compared adequately with *H. marsupialis* and we may therefore take it as a representative form of the genus. This mite, *H. capensis,* is discussed further under *H. geomys.*

Berlese eventually removed *Haemolaelaps* from *Laelaps* and placed it as a subgenus of *Hypoaspis.* Here Vitzthum also places it in his monumental work, "Das System der Acari" (1941). However, when Vitzthum described *Hypoaspis cricetophilus* (1930) (which is a synonym of *H. glasgowi*) he stated that it was intermediate between *Hypoaspis* and *Laelaps.* Actually *Haemolaelaps* as here understood does have many characters in common with *Hypoaspis,* such as only one pair of setae on the genitoventral plate, no heavy spines on the coxae, and slender body setae. But I believe the structure of the male chelae, the relatively few teeth per row on the hypostome, and the large, membranous structure on the anterior portion of the epistome indicate a closer relationship to *Laelaps* than to *Hypoapis.* However, in my opinion, it differs sufficiently from either genus to be accorded full generic rank.

The genus *Atricholaelaps* was never recognized outside of the United States due no doubt to the fact that it was so poorly described that it was impossible to recognize it. The genotype was, "Described from a single female taken from a female skin of *Reithrodon cuniculoides* collected at Huanuluan, Territory of Rio Negro, Argentina" (Ewing 1925, p. 7). Figure 26 is a camera lucida sketch of the specimen and shows it as it is. Those appendages not shown in the drawing are missing from the type. The extent of the dorsal plate is indicated by the dotted line. Most of the dorsal setae are lost but those remaining are of medium length and thickness. Details of the chelae are very difficult to make out but there is a circlet of small setae at the base of the digitus mobilis and apparently the seta on the digitus fixus is only slightly inflated (Fig. 25). The corniculi seem to be much more prominent and falciform than in other species. The unsclerotized portion of the venter is somewhat shrunken and convoluted, and it is very difficult to find the metapodal plates. The specimen contains a larva.

The genus *Ischnolaelaps* although not illustrated and not too well described was recognized both in this country and in Great Britain, probably because Fonseca supplied some of the British acarologists with representative specimens. Radford described several new species under this name (1939) but later (1942) he reverted to the use of *Haemolaelaps* for a species which obviously belongs to the same genus as those he earlier described as *Ischnolaelaps.* I want to take this occasion to pay a debt of gratitude to Dr. Radford, now of the British Museum, for the loan of slides of type and paratype material of his species, and for a slide of *Ischnolaelaps sciurinus* Fonseca determined by Fonseca himself. If this specimen is indeed a true representative of *Ischnolaelaps,* then there can be no doubt that the synonymy given above is correct.

Fonseca in commenting (private correspondence) on the similarity of *Ischnolaelaps and Haemolaelaps* says that he placed reliance on the fact that Berlese described the pilus dentilis as being long and thread-like whereas in *Ischnolaelaps* the pilus dentilis is inflated and curved. Also, Fonseca adds, the genotype, *H. mar-*



EXPLANATION OF PLATE III

Haemolaelaps geomys

FIG. 12. Ventral view of male.
FIG. 13. Ventral view of female.
FIG. 14. Chela of male.
FIG. 15. Dorsum of female.

supialis was from a primitive marsupial, from which one would expect to recover uncommon parasites. The shape of the pilus dentilis, although very valuable as a specific character is not necessarily a good generic character, as can be seen from the description of the four species given below. The fact that a specimen was taken from a marsupial means very little as it could easily have been an accidental record.

CHARACTERS OF THE GENUS

Less than 1 mm. long, ovoid-elliptic in shape but with noticeable shoulders at the anterior end. The legs are non-calcarate and relatively long and slender. Both they and the body are uniformly but not thickly beset with setae of moderate length and thickness. In the female the genitoventral plate is broadened below coxae IV, broadly rounded posteriorly, never reaches the anal plate, and bears only one pair of setae. None of the coxae have a heavy spine and femora I and II do not have a pair of long setae dorsally. The sternal plate is wider than long. The male chela has a short and weak digitus fixus and a long, prominent spermatophore carrier.

Dorsum, male and female. The dorsal plate in both sexes is undivided and covers all but a slight posterior and lateral periphery. This plate is generally elliptical in outline with the widest point at the middle (about the level of legs IV) but may be somewhat oval with the widest point about at the level of legs II. Shoulders at the anterior side are generally quite pronounced. The peripheral setae are longer than the medial ones, generally quite noticeably so, and very slightly feathered on the outer side. As a rule the posterior marginal pair of setae is the longest and the two pairs of setae immediately anterior are the smallest. There are approximately 35–40 pairs of setae and numerous small circular and slit-like pores. These pores seem to be in some definite arrangment but this has not been established. The setae are arranged in definite patterns but this pattern frequently breaks down, especially on the posterior part of the plate. The plate is well sclerotized and covered with a reticulation of fine lines. The nonsclerotized portion of the dorsum is finely striated and bears setae which are equal in length to those on the periphery of the dorsal plate and generally slightly feathered, especially the most posterior ones.

Venter, female. The sternal plate is always broader than long and the posterior margin is always concave. It is well sclerotized, bears three pairs of prominent setae and two pairs of slit-like pores, and projects between coxae I and II and coxae II and III. A reticulation of fine lines is always present. The presternal area is generally noticeably sclerotized, sometimes so well that it is difficult to define the anterior margin of the sternal plate. In our species the anterior sternal setae arise from the anterior margin of the plate.

The endopodal plate is a narrow, poorly defined, slightly bow-shaped plate lying close to coxae III and IV and extending from the posterior margin of the sternal plate to the middle of coxae IV. The endopodal seta arises just inside the concavity of this plate.

The genitoventral plate is more or less expanded posteriorly, bears only a single pair of setae and the posterior margin is always convex, even though it may closely approach the anal plate. The anterior margin is poorly defined and approaches, or perhaps overlaps the posterior margin of the sternal plate. The genital orifice lies between these two plates. A series of indistinct folds or creases are seen at the genital orifice and these apparently represent the relaxed folds of a greatly dilatant pore. The posterior (and most heavily sclerotized) portion of the plate has typically one steeply and one slightly arched line and three more nearly transverse, backwardly bent lines. Slight variations and one or two cross lines are common but the lines never form a network as they do in some *Hypoaspis*.

The metapodal plates are typically three on each side; a tiny one lying close to the genitoventral plate, a large one lying posterior to the apical end of coxa IV, and a tiny one between these two. The large plate is the only conspicuous one.

The anal plate is triangular, with rounded corners although in some species it is more nearly ovate or pear-shaped. The paired anal setae are opposite the middle of the anal pore and are subequal in size with the odd seta. The unsclerotized portion of the venter is finely striated and bears a minimum of seven setae, including the three pairs that normally belong to the ventral plate. The number generally varies between 7 and 12 pairs in our species but may be more in some exotic forms. The side of the mite is evenly rounded so that there is no distinct transition from dorsum to ventor and consequently care must be excercised in counting either the dorsal or ventral setae.

Stigma and *peritreme*. The stigma opens between coxa III and IV and the peritreme extends forward in a slightly sinuate course to the middle of coxa 1. A short, weekly sclerotized

area, the peritrematalia, extends posteriorly from the stigma and bears a small pore at its apex.

Venter, male. The holoventral plate of the male is suddenly expanded behind the fourth coxae. It bears 10 or 11 pairs of setae in addition to the three anal setae, and three pairs of pores, one below each of the first three setae. A network of fine lines is always noticeable, and, as in the female, the presternal area is sclerotized. The setae are variable in length but the first pair never extends much beyond the base of the second pair. In the genus *Laelaps sensu strictu* the first seta generally reaches the base of the third seta. The nonsclerotized portion is finely striated and bears a variable number of setae, generally 10–15 pairs, of which at least the posterior ones are inconspicuously feathered. In occasional specimens the posterior part of the holoventral plate will have poorly developed margins. In some cases the plate is narrow between the anus and coxa IV, as in liponyssids, in others there are simply eroded areas along the margin and occasionally some of the marginal setae will be on a sclerotized plate and separated from the plate proper by an unsclerotized area. In such specimens with poorly developed holoventral plates the posterior setae are much longer than usual and the hind legs are heavier and longer.

Male and *female.* The tritosternum is well developed and is closely and finely setaceous. It branches well above the basal segment and the branches are relatively thick, differing in this respect from the hypoaspids in which the tritosternum branches near the basal segment into two much narrower branches and with longer and more prominent pinnae.

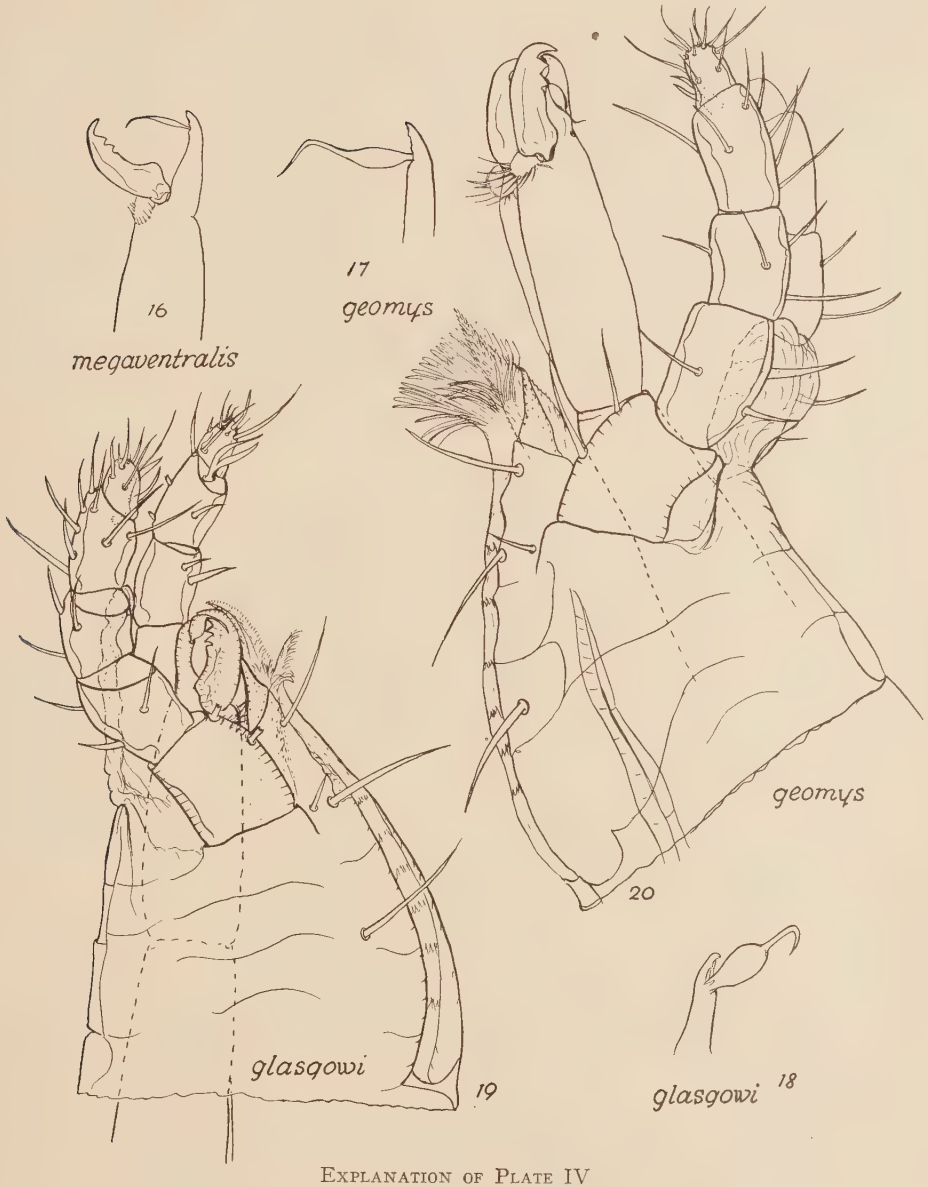
The legs are relatively slender and long, with moderate setae. In decreasing order of length they are IV, I, III, II. Leg II is the heaviest in both sexes. Coxa I has two submarginal setae, lying on or just posterior to the midventral line, one apicad the other basad. Coxae II and III each have an anterior marginal seta and a submarginal seta posterior to the midventral line. Coxa IV has only a single, small seta just below the ventral point of articulation. None of these setae is heavy or spine-like. In addition, coxa II has a triangular tooth-like projection from the anterior border. This projection is a family characteristic and is most strongly developed in some of the LIPONYSSINAE. The apical margins of coxae I and II are slightly fimbrillate on the dorsal side. Except in some males, the heaviest setae are on the tarsi of legs II, III, and IV. The apex of tarsus I has a group of long, slender setae which obviously serve a tactile function and critical study should reveal a definite pattern of sensory setae (see Haarløv, 1943). The setae on the dorsal side of femur I and II are of uniform length, unlike *Laelaps sensu strictu* which has a pair of long setae on these segments.

The gnathosoma has no unusual features. The epistome consists of a weakly sclerotized basal portion which reaches about as far as the apex of the first palpal segment, and a nonsclerotized, membranous, poorly visible and poorly defined anterior portion, which extends to or beyond the second palpal segment. This is best seen in a side mount of the gnathosoma. (Figs. 19 and 20). Apparently this membranous part is destroyed by strong clearing agents such as KOH, as specimens that are processed in this manner never show this structure. The hypostome is a relatively narrow, nearly parallel-sided groove with six transverse rows of small teeth, with from 3–5 teeth per row. The chelae of the female are well developed and characteristically toothed. The movable arm is larger than the immovable, with a strongly hooked apex and two strong teeth below. At its base there is always a semicircle of small setae. The immovable arm has one or two teeth beneath the slightly bifid apex and always has a modified, more or less inflated seta near the apex. The shape of this seta is specific and hence an important taxonomic character.

One of the most difficult structures to demonstrate is the single spine-like seta at the base of the digitus fixus. Unless the chela happens to lie in exactly the right plane, this seta is impossible to see. The few times that I have been able to see it at all, I was never quite sure whether it was actually a seta or simply an artifact. For this reason I have always refrained from showing it in my illustrations of chelae. But in the recently discovered *H. morlani* this seta was clearly visible and it is shown in the drawing of the chela of that species. (Fig. 8). It probably occurs on the other species as well.

The male chelae are modified as spermatophore carriers and the details of their structure are difficult to ascertain. Apparently both arms are present. The immovable arm is small and weak, the movable is larger and has attached to it the very long spermatophore carrier. A row of small setae is usually visible at the base of the movable arm.

Immature forms. Larva. As in most mesostigmatic mites, the larvae of *Haemolaelaps* are 6-legged and lack the stigma and peritreme. I doubt, however, if the larva ever exists free of its mother as I have never been able to find one in a colony maintained in our laboratory. One frequently finds pregnant female mites in which the perfectly formed larva is visible but one finds quite as many females containing the protonymphal form. Hence I am of the opinion



EXPLANATION OF PLATE IV

FIG. 16. Chela of *H. megaventralis,* female.
FIG. 17. Digitus fixus of *H. geomys,* female.
FIG. 18. Digitus fixus of *H. glasgowi,* female.
FIG. 19. Side view of gnathosoma of *H. glasgowi,* female.
FIG. 20. Side view of gnathosoma of *H. geomys,* female.

that the larval stage is passed in the body of the female and birth is given to the first nymphal stage.

Protonymph (Figs. 21, 22, 24.) The first nymphal form, or Nympha I, is whitish in color and poorly sclerotized. The peritreme is very short, reaching only to the middle of coxa III. The dorsal side has a large anterior shield with about eleven pairs of setae, and a smaller posterior shield bearing eight pairs of setae. Three pairs of small, rather indistinct, nonsetiferous platelets lie between the two large ones. The ventor shows a sternal shield which is about twice as long as wide, bears three pairs of setae and lies between the bases of the legs II and III. The anal plate is more or less circular and poorly defined. The mouth parts are similar to those of the female. In fact it is possible to assign the protonymph to species by the shape of the seta on the digitus fixus.

Deutonymph (Fig. 23). The second nymphal stage, or Nympha II, is quite similar to the female but is not so deeply pigmented. The dorsal shield is entire and covers most of the body. The peritreme reaches the base of coxa I. The single sternal shield reaches from the base of coxae I to the level of the posterior border of coxae IV. It has four pairs of marginal setae and three pairs of pores. The metapodal plates are present and the anal plate is only slightly less triangular than in the female. As in the protonymph, the gnathosoma of Nympha II is like that of the female. Deutonymphs are generally of two sizes and evidently the size presages its future male or female being. Whether differences other than size exist I have been unable to determine.

Key to the Species

Females

1. Pilus dentilis strongly inflated; body setae rather coarse 2
   Pilus dentilis slender, slightly or not at all inflated; body setae relatively delicate 3
2. Anal plate triangular; the slender terminal portion of the pilus dentilis strongly recurved; legs IV about as long as the dorsal plate ..... *glasgowi*
   Anal plate slightly arched; slender portion of the pilus dentilis bent at right angles; legs IV longer than the dorsal plate; labium with a brush of long setae ..... *geomys.*
3. Genitoventral plate large, nearly touching the anal plate; tarsus I about 160 μ long ..... *megaventralis.*
   Genitoventral plate separated from the anal plate by at least the length of the anal pore; tarsus I about 190 μ long ..... *morlani.*

Males

1. Spermatophore carrier longer than the segment from which it arises, strongly recurved ..... *glasgowi.*
   Spermatophore carrier of the chela no longer, or not as long as the segment from which it arises and not strongly recurved although the tips are bent inward slightly 2
2. Legs stout; the femur, genu, and tibia of leg II each with a strong spine ventrally; body setae relatively coarse; a brush of long seta-like structures on the labium ..... *geomys.*
   Legs and body setae delicate; no spines on leg II; no brush of setae on the labium ..... *megaventralis.*

Nymphs

1. Brush of long setae on the labium (as in the male and female) ..... *geomys.*
   No such brush 2
2. Pilus dentilis strongly inflated ..... *glasgowi.*
   Pilus dentilis slender ..... *megaventralis.*

Haemolaelaps megaventralis (Strandtmann, 1947)

Figs. 1, 2, 3, 4, 5, 16 and 24

1947. *Atricholaelaps megaventralis* Strandtmann, p. 112.

Female. Additional material which has accrued since this species was first described makes it necessary to modify slightly the measurements given for the female in the original description. The only significant difference however is in the length of the genitoventral plate. In the original description this was given in error as 226 microns; it should have read 326 microns. The average measurements are: TL–665 μ; TW–435 μ; DL–640 μ; DW–420 μ; SL–92 μ; SW_1–120 μ; SW_2–173 μ; GVL–320 μ; GVW–150 μ; AL–98 μ; AW–108 μ; GV to A–17 μ; L I–560 μ; L IV–580 μ; LT I–157 μ; WT I–27 μ.

Male (Plate I). About 0.5 mm. long and with slender legs and weak setae like the female. The ventral setae are quite short, no one of them reaching much beyond the base of the next. The long arm of the chela is nearly straight and rather broad, and only a trifle longer than segment that bears it. Length—500 μ; width—333 μ; leg I—440 μ; leg IV—500 μ. It may be differentiated from *H. glasgowi* by its much shorter spermatophore carrier and from *H. geomys* by its shorter setae and lack of spurs on leg II.

Deutonymph. I have seen only one specimen of this form. It is similar in general to the deutonymphs of the other species but may be differentiated from them by the finer setae, a nearly circular anal plate, more slender legs, and by the straight, slightly inflated seta on the digitus fixus.

Protonymph Fig. 24. This stage has a much more slender and slightly longer peritreme than that of the other species. The seta of the digitus fixus is characteristic and serves readily to differentiate it. The pattern of the setae and plates is like that of *H. glasgowi.*

Through the courtesy of Dr. E. W. Baker I was able to see a collection of 17 slides of this mite taken from a colony of white mice in Hamilton, Montana. This collection contained two males, a deutonymph, and several females with protonymphs. From H. B. Morlan I received a protonymph taken from a flying squirrel at Thomasville, Ga. This latter slide, and a male and the deutonymph from Hamilton have been designated allotypes and are in the United States National Museum, as is also the holotype female.

Hosts and distribution. Although this mite has been taken from a fairly large number of mammals it seems to show a decided preference for birds and tree squirrels. It is the only species of *Haemolaelaps* that has been taken from the flying squirrel, *Glaucomys volans.*

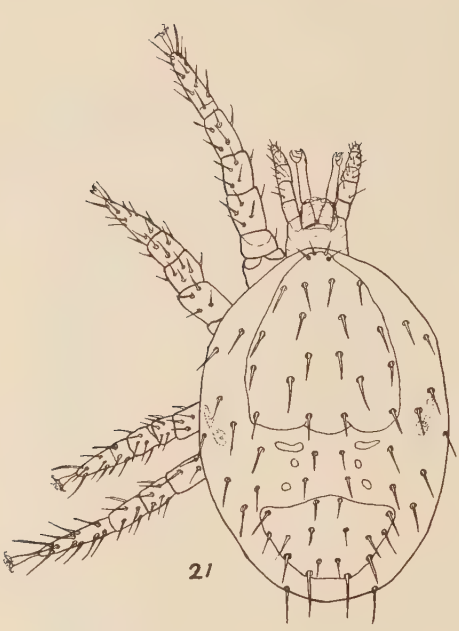
The collection records indicate that the mite may probably be found throughout North America and the world. It has been taken from mammals and birds in British Columbia, Montana, Colorado, Texas, Arkansas, Florida, Georgia, South Carolina, Virginia, Ohio and Pennsylvania. It has been intercepted by Bureau of Entomology and Plant Quarantine inspectors at Atlantic, Pacific and Gulf Coast ports, at Mexican and Canadian border stations and at the Hawaiian Islands. The origin of these interceptions includes: Canada, Mexico, Peru, Chili, Uruguay, Australia, Java, Granada, Italy, Portugal, Scotland, England, the Netherlands, Holland, and Poland.

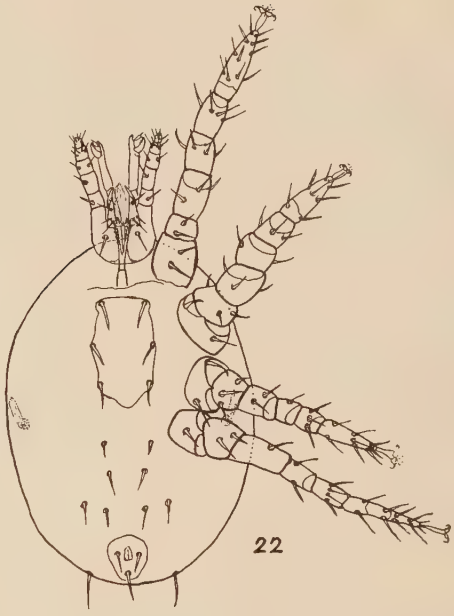
Remarks. It was not until after the description of *Atricholaelaps megaventralis* had been published that I had occasion to see Willmann's (1939) fine paper on *Haemolaelaps molestus* Oudemans. I was so struck by the similarity between his description and illustrations and that of mine that I greatly feared I had created a synonym and accordingly forwarded several specimens to Dr. Willmann for his opinion. He very kindly obliged and wrote in effect that although closely related, *H. molestus* is coarser throughout, more heavily sclerotized and has stronger setae. Also the pilus dentilis is somewhat heavier and strongly bent whereas the pilus dentilus of *megaventralis* is slender and only slightly bent at the apex. He adds further that *H. molestus* may be found in very large numbers in new hay, straw, etc. but that it has never been found parasitic.

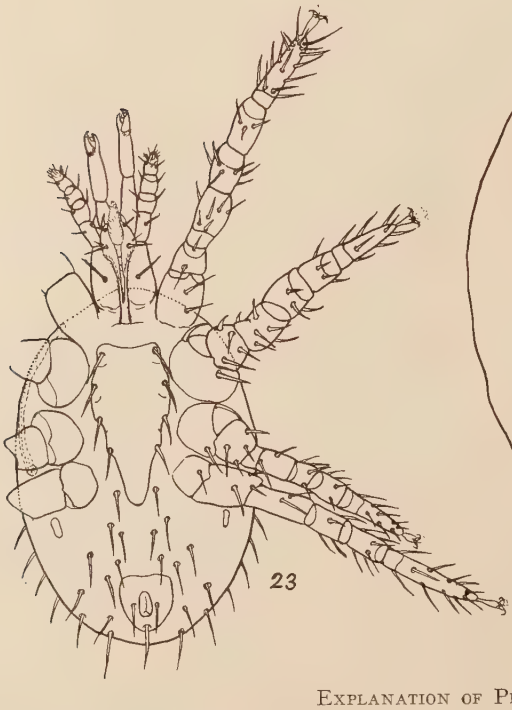
Haemolaelaps morlani, female

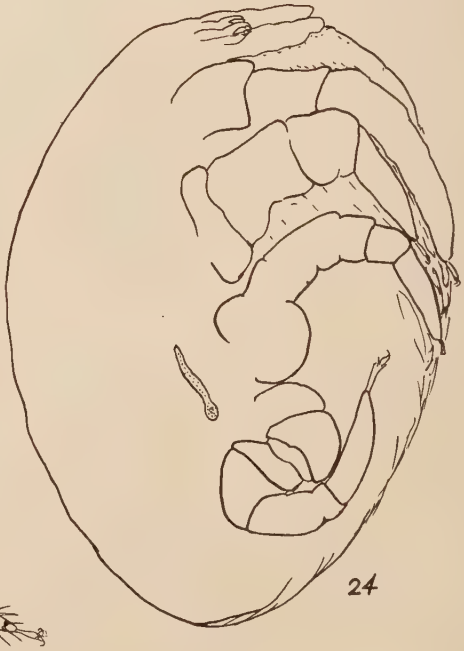
Figs. 6, 7, 8, 9, 10, 11

Female (Plate II). A delicate, slender-legged mite with relatively weak setae. Tarsus I is unusually long for the size of the mite. Leg II has rather heavy setae ventrally on the genu, tibia and tarsus. Leg IV is slightly longer than the dorsal plate. The anal plate is









EXPLANATION OF PLATE V

Immature forms

FIG. 21. Dorsal view of protonymph. (*H. glasgowi*).
FIG. 22. Ventral view of protonymph. (*H. glasgowi*).
FIG. 23. Ventral view of deutonymph. (*H. glasgowi*).
FIG. 24. Sketch of unborn protonymph. (*H. megaventralis*).

only vaguely triangular, being more pear-shaped than anything. The anal pore is approximately in the middle of the plate and the three anal setae are equal. The sternal plate is more nearly equilateral than in the other species treated here. The larger metapodal plates are slender oblong; the smaller ones I could not clearly differentiate in the specimens at my disposal. The claws of all legs are quite small.

The measurements given below are the average of ten specimens. Variations from the mean were slight, about ± 3%. TL–644 μ; TW–440 μ; DL–640 μ; DW–430 μ; SL–100 μ; SW–113 μ; GVL–257 μ; GVW–133 μ; AL–93 μ; AW–87 μ; GV–A 50 μ; L I–600 μ; L IV–650 μ; T I–187 μ.

Male and immature forms are unknown.

Types. Designated as cotypes are five females on a slide bearing the following data: G—4003, Grady Co., Ga., Mar. 23, 1948. Host *R. rattus.* H. B. Morlan. The drawings were made from one of these specimens. The slide is in the U. S. National Museum.

Type host. Rattus rattus (Linnaeus). The black rat.

Type locality. Grady Co., Georgia.

In addition to the cotypes there are 15 paratypes, all from Grady Co., Georgia, as follows: from *R. rattus,* #4003, Mar. 23, 1948, 9 specimens; #4018, Mar. 24, 1948, 3 specimens; from *R. norvegicus,* #4127, Apr. 7, 1948, 2 specimens.

Remarks. The delicate habitus, weak setae and slender pilus dentilis of this mite indicate a close relationship with *H. megaventralis* but much more information is needed on this mite. One wonders why it was not sooner discovered in an area as intensively collected as Grady Co., Ga., and whether the common rat is really the only host.

The species is named for that excellent entomologist and indefatigable worker, Harvey B. Morlan, P. A. Sanitarian, U. S. P. H. S. who has collected very large numbers of ectoparasites from mammals in south Georgia, including several new species.

Haemolaelaps geomys n. sp.

Figs. 12, 13, 14, 15, 17, 20

Female (Plate III). Leg IV is always longer than the dorsal plate. Leg I is nearly as long as the dorsal plate. Membranous expansion of the labium always with a brush of long, slightly inflated, delicate setae (Fig. 20). Anterior margin of anal plate strongly arched, although not always as much so as is shown in the accompanying figure. The number of ventral setae varies from 7 to 12 pairs. The two pairs of minute metapodal platelets apparently lacking, the largest, however, is present and clearly defined.

Male (Plate III). Membranous expansion of the labium with a brush of setae as in the female. Leg II with a heavy spine ventrally on each of the four apical segments. Posterior portion of the holoventral plate sharply triangular, as shown in the drawing. The anterior setae on the holoventral plate reaching to the base of the second pair.

The following four pairs are very long, each overlapping the base of the following and reaching the base of the next beyond.

Immature forms. The nymphal forms are similar to other *Haemolaelaps* but may be distinguished by the presence of the labial brush.

The measurements given below are the average of twelve specimens. Variations either side of the mean were slight. Female TL–782 μ; TW–533 μ; DL–726 μ; DW–462 μ; SL–88 μ; SW_1–140 μ; SW_2–200 μ; GVL–306 μ; GVW–112 μ; AL–102 μ; AW–120 μ; GV–A–103 μ; L I–720 μ; L IV–800 μ; TIL–192 μ; TIW–38 μ.

The male measures about 674 μ long by 433 μ wide. Leg I is 693 μ and Leg IV is 813 μ.

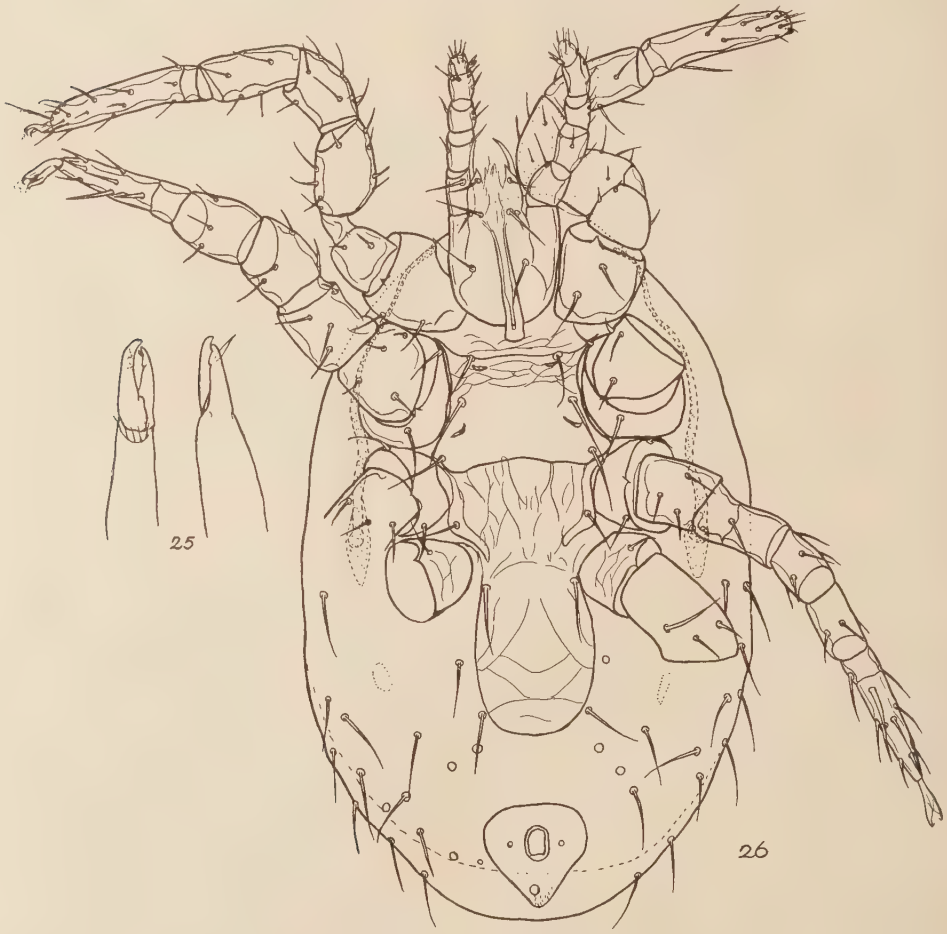
Types. Designated as cotypes are two females, one male and one deutonymph mounted on three slides which are deposited in the U. S. National Museum. These specimens were collected from the pocket gopher March 21, 1947, Brooks Co., Georgia, by H. B. Morlan.

Type host. Geomys sp. Pocket gopher.

Type locality. Brooks Co., Georgia.

Hosts and Distribution. This is truly a host specific mite. It has been recorded only from rodents of the family Geomyidae, including species of *Geomys, Thomomys* and *Cratogeomys.* There are two records, each of a single specimen, from *Peromyscus* and *Neotoma* which I feel sure may be regarded as accidental. Incidentally, no other species of *Haemolaelaps* has been taken from the pocket gophers. It has been recorded from widely scattered points in the United States, including Florida, Georgia, Texas, Nebraska, Illinois, Oregon and California, and probably occurs wherever its host, the pocket gopher is to be found.

Remarks. This species is quite similar at first glance to *H. glasgowi.* However, the opisthosomal region is relatively shorter, the legs are considerably longer, and the body appears more hirsute. In many respects the mite is similar to *H. capensis* Hirst, 1916. In both species the female has a pear-shaped rather than triangular anal plate and the male of both have a very heavy seta on the femur. However, the



reithrodontis

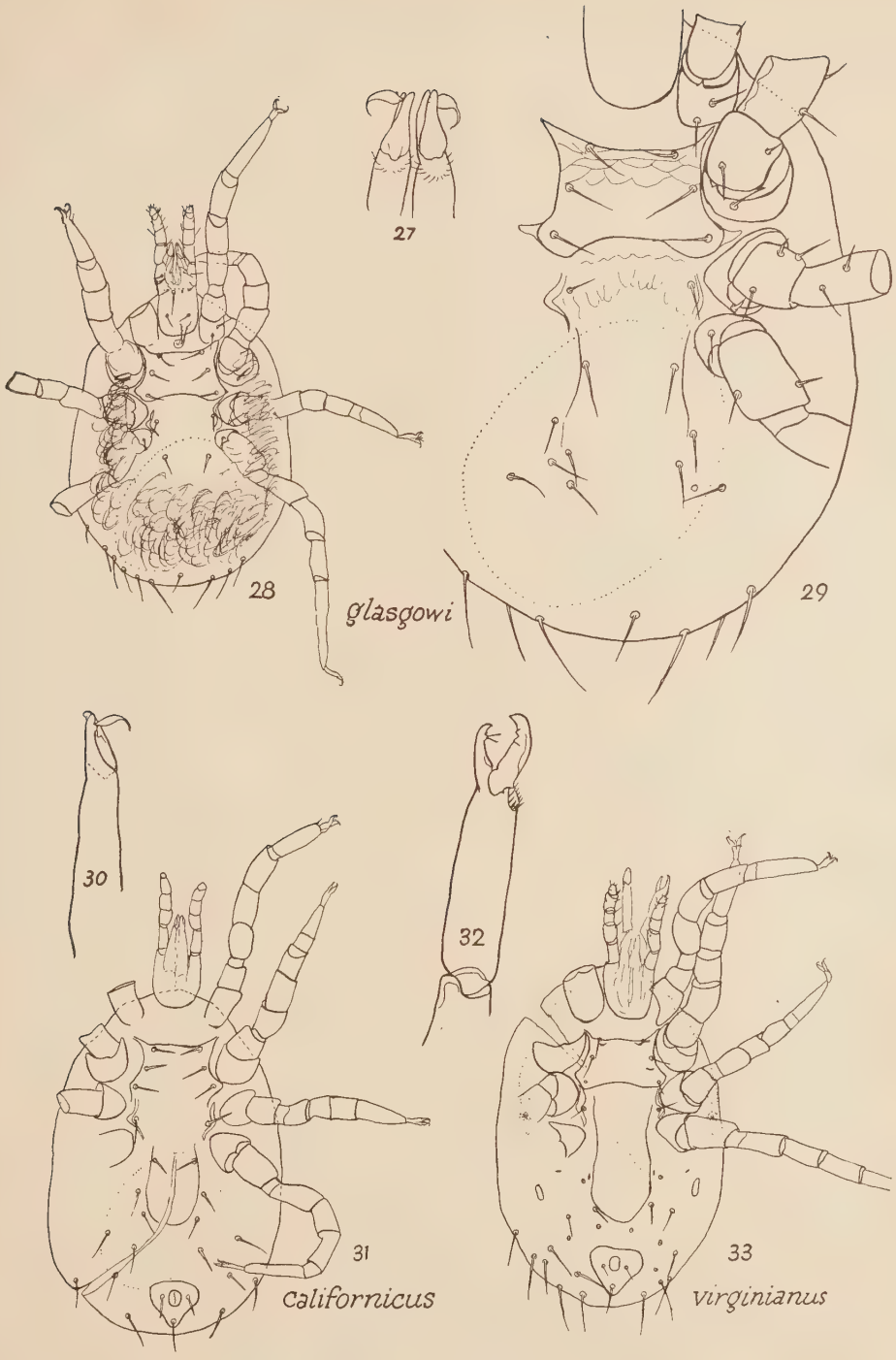
EXPLANATION OF PLATE VI

Laelaps reithrodontis Ewing, genotype of *Atricholaelaps.*

FIG. 25. Chelae.
FIG. 26. Ventral view.

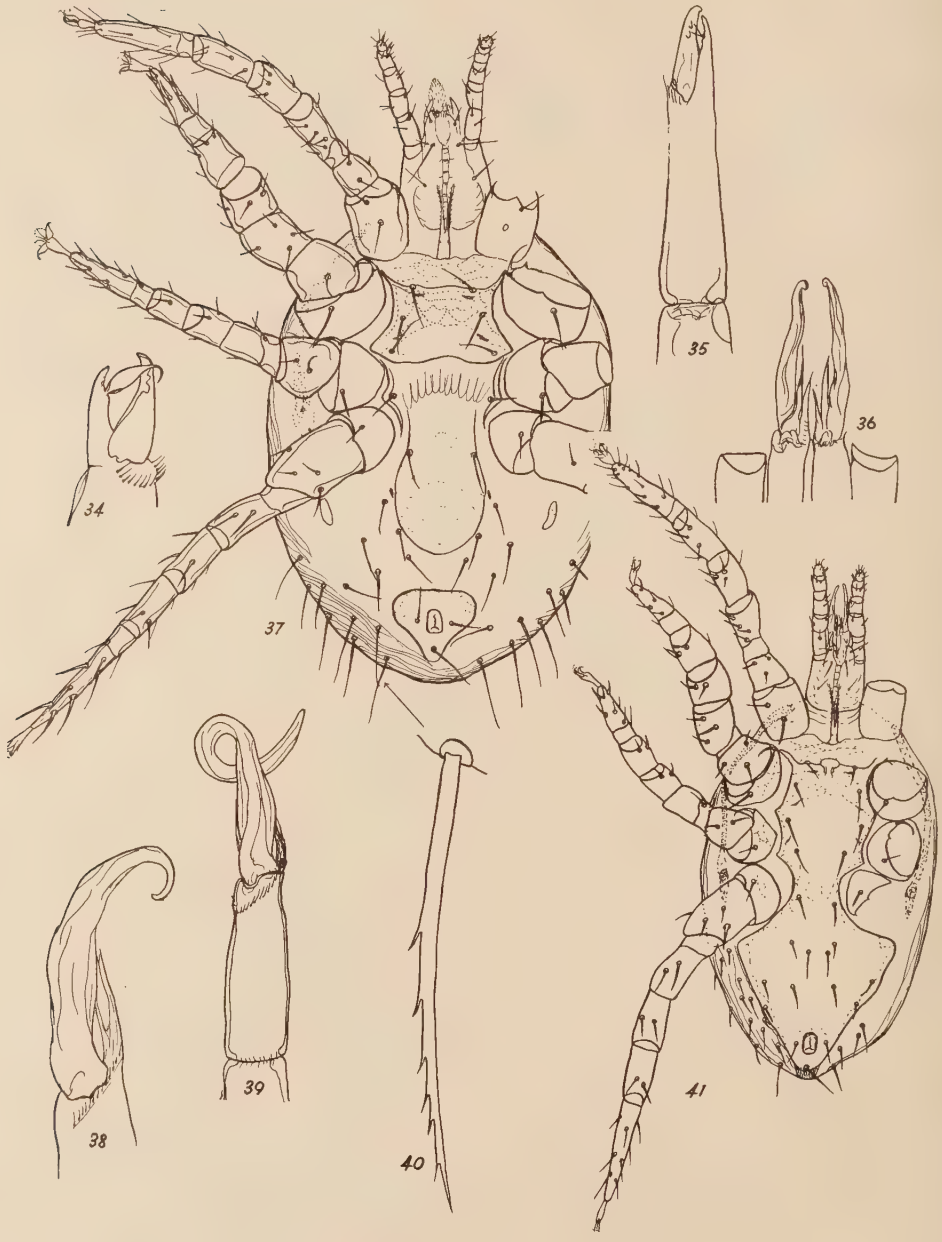
female of *H. capensis* is larger (0.96 mm), has weaker setae, the pilus dentilis is only slightly inflated and it lacks the brush of long setae on the labium. The male on the other hand is smaller (0.56 mm), the legs are relatively more slender and it lacks a heavy seta on the genu of Leg II.

Randolph and Eads (1946, p. 599) incorrectly referred to this mite as *Atricholaelaps sigmodoni* from *Geomys texensis.*



EXPLANATION OF PLATE VII

FIG. 27. Chelae of *Laelaps glasgowi* Ewing, type specimen.
FIG. 28. Ventral view of *L. glasgowi* Ewing, type specimen.
FIG. 29. Same as Fig. 28, enlarged.
FIG. 30. Chela of *Laelaps californicus* Ewing, type.
FIG. 31. Ventral view of *L. californicus* Ewing, type.
FIG. 32. Chela of *Laelaps virginianus* Ewing, type.
FIG. 33. Ventral view of *L. virginianus* Ewing, type.



EXPLANATION OF PLATE VIII

Haemolaelaps glasgowi

FIG. 34. Chela of deutonymph. (ex *Sigmodon hispidus*).
FIG. 35. Chelicera of female. (*H. scalopi* Keegan, type).
FIG. 36. Chelicera of male. (ex *Blarina brevicauda*).
FIG. 37. Ventral view of female. (ex *Blarina brevicauda*).
FIG. 38. Chela of male. (ex *Neotoma* nest).
FIG. 39. Chela of male. (ex *Sigmodon hispidus*).
FIG. 40. Posterior body seta, greatly enlarged.
FIG. 41. Ventral view of male. (ex *Blarina brevicauda*).

Haemolaelaps glasgowi (Ewing, 1925)
Figs. 18, 19, 21, 22, 23, 27 to 45

1925. *Laelaps glasgowi* Ewing, p. 6.
1925. *Laelaps californicus* Ewing, p. 5.
1925. *Laelaps virginianus* Ewing, p. 6.
(?) 1930. *Hypoaspis cricetophilus* Vitzthum, p. 417.
1935. *Laelaps stegemani* Hefley, p. 22.
1946. *Haemolaelaps scalopi* Keegan, p. 71.
1946. *Atricholaelaps sigmodoni* Strandtmann, p. 164.
(?) 1947. *Atricholaelaps strandtmanni* Fox, p. 598.

Other references are: MacCreary, 1945, p. 126; Rumreich and Wynn, 1945, p. 890 & 892; Gerhardt, 1945; Randolph and Eads, 1946, p. 599, 600; Cole and Koepke, 1946, p. 1472, 1473, 1478; Pratt, 1947; Ewing, 1947, p. 84; Jameson, 1947, p. 142; Grant, 1947, p. 11.

The detailed descriptions given under characters of the genus, plus the illustrations, should be sufficient for the identification of this mite complex. The average size of the female is about 700 μ long by 450 μ wide. There are certain intraspecific differences that become apparent when comparing specimens from one host with those from another. Primarily these are differences in relative measurement and since there seem to be no other reliable structural differential characters associated with them, I have deemed it inadvisable to create a host of varietal names. Since these differences of size were impossible to correlate with either geographic or seasonal distribution but apparently showed a close correlation with hosts, the specimens were divided into groups according to host genus and measurements taken of parts as listed on page 4. Great care was exercised to obtain measurements only from normally expanded specimens and only females were included. All measurements were made with a Zeiss Contrast Micrometer at a magnification of 10× by 10×. In order to convert the measurements listed below into microns it is necessary to multiply by a factor of 13.33. The measurements were subjected to statistical analysis and the standard small sample t-test was used to test for significance of differences of means.

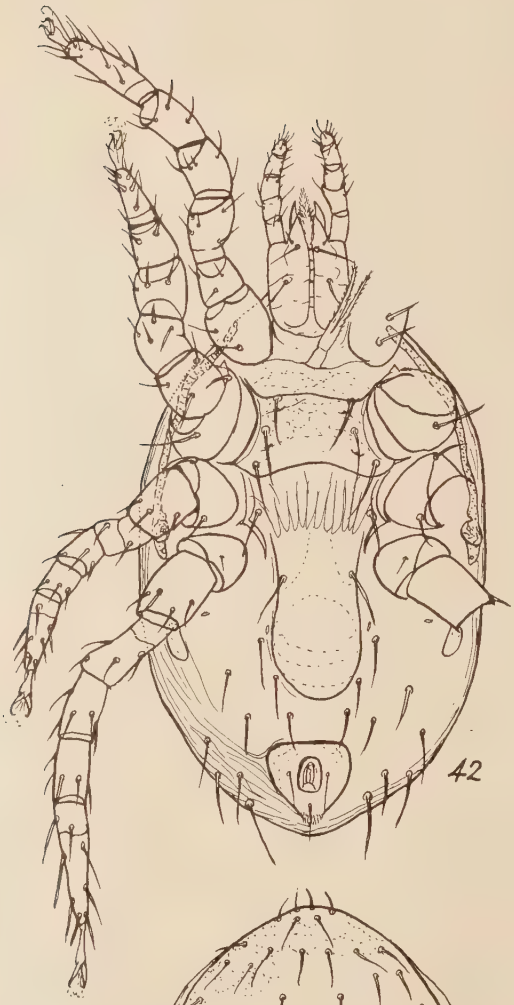
There were more specimens from *Peromyscus* than from any other genus and so it was decided to use these mites as the representative form of the species *H. glasgowi* and all comparisons were made with it. The results are given in the accompanying table.

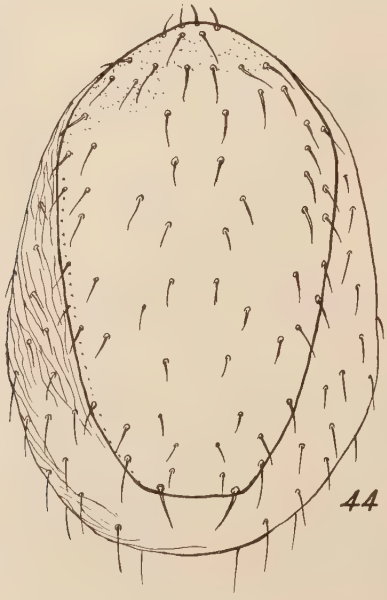
In studying the analysis of the data, one notes that mites from *Blarina* are essentially the same as those from *Peromyscus,* being significantly different in only one respect, the anal plate being wider. Mites from *Sigmodon* differ in three respects, the sternal plate is shorter, the anal plate is longer and the space between the anal and genitoventral plate is greater. It also seemed that the dorsal setae were longer but these were not measured.

From the opossum only a very few measurements were available but these were subjected to test as I thought the fore tarsus seemed longer than normal. This proved of no significance but the length and width of the dorsal plate, as well as the width of the anal plate were significantly larger.

Mites from *Pitymys* and *Cynomys* differed significantly in five of the fourteen measurements made.

Mites from *Napeozapus* and from *Microtis* each differed significantly in nine of





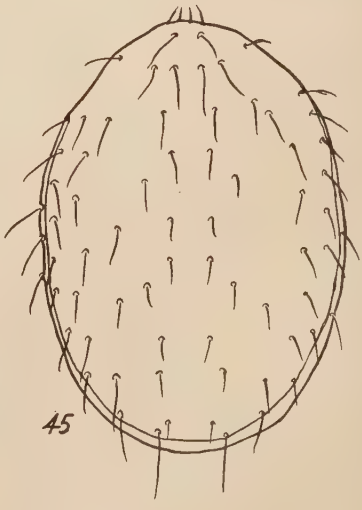


PLATE IX

the measurements but the degree of difference in *Napeozapus* is much greater. There were a few measurements of mites from *Zapus* and also from *Phenacomys* which agreed very closely with those from *Napeozapus*. Not only is the mite smaller in all respects but the legs are noticeably shorter in relation to the body; note particularly that the hind leg is considerably shorter than the dorsal plate.

Mites from *Oryzomys* are significantly larger in eleven of the measurements but some material I have seen recently from this genus was no larger than material from *Peromyscus*.

Of particular interest are the results obtained from the analysis of measurements on mites from *Marmota*. Note especially that the dorsal plate is significantly longer but that the width is almost the same as for *Peromyscus*. Fig. 44 shows the plate to be oval rather than elliptic in outline. Also the distance between the anal and genitoventral plates is much greater than in any other form. However, no other structural differences could be noted and it did not seem advisable to create a new species on the basis of this feature alone. It should also be mentioned that in some specimens the anterior margin of the anal plate appeared arched, as in *H. geomys*. It may well be that a study of fresh material from *Marmota*, including males as well as females, may show other differences and make it necessary to place these mites in a separate species. No males from this host were available to me.

The measurements in Table I represent only ten genera of hosts. No other genera were included because the number of obtainable measurements were too few. An adequate number was available from *Rattus spp.* but they were purposely omitted as I do not believe that the domestic rat can be considered a normal host for *Haemolaelaps glasgowi* and that mites from them cannot be assumed as representing a homogenous population.

Occasional males are considerably larger than the average, have longer and more robust legs, and the posterior body setae are two or three times longer than in average males. All such males have an incompletely developed holoventral plate, i.e., the posterior portion is not expanded. Exactly the same condition was noted by Vitzthum in *Hypoaspis cricetophilus*. Of the two males he had, one was normal, the other as above. Males of this type were most frequently encountered by us in material from *Microtis* but occasional ones were seen from *Peromyscus* also. They average as follows: length 640 μ; width 400 μ; Leg I 490 μ; Leg IV 633 μ. Normal males average: length 520 μ; width 320 μ; Leg I 430 μ; Leg IV 520 μ.

Hosts. We have records of this mite from the downy woodpecker, bank swallow, rough-winged swallow, shrike, towhee, song sparrow, and burrowing owl; also from opossum, moles, shrews, little gray bat, raccoon, weasel, skunk, fox, woodchuck, ground squirrels, prairie dogs, chipmunks, tree squirrels, pocket mouse, kangaroo rat, grasshopper mouse, harvest mouse, *Peromyscus spp.*, rice rat, cotton rat, woodrat, rufus tree mouse, red-backed mouse, meadow mouse, pine mouse, roundtailed muskrat, house mouse, domestic rat, jumping mouse, jackrabbits, and cotton-tail

EXPLANATION OF PLATE IX

Haemolaelaps glasgowi

FIG. 42. Ventral view of female from *Phenacomys longicauda*.
FIG. 43. Ventral view of female from *Marmota monax*.
FIG. 44. Dorsum of female from *Marmota monax*.
FIG. 45. Dorsum of female from *Peromyscus gossypinus*.

rabbits. It is common on opossum, moles, shrews and the rodents. Records from the bat, the carnivores, and the birds are single specimen records and these animals therefore should probably not be regarded as true hosts. For a detailed list of the hosts see the Classified List of Hosts.

Distribution. This mite is our most common species of *Haemolaelaps.* Our records include Alaska, southern Canada and every state of the Union except Rhode Island, Kentucky, Indiana, Iowa, Missouri, Louisiana, Oklahoma, North Dakota, New Mexico, and Nevada. We also have one record from Angol, Chili (from *Oryzomys sp.*) and it has been intercepted by quarantine inspectors in shipments originating in Cuba, Mexico, and Guatemala.

Remarks. When Ewing described the genus *Atricholaelaps* (1929) he selected as type the South American species *Laelaps reithrodontis* Ewing, but did not list any other described species as belonging to this genus, merely saying that "many species of *Laelaps* that are devoid of spine-like setae have less than four pairs of setae on the genitoventral plate. They are placed in *Atricholaelaps.*" But the type slides of *Laelaps californicus, L. virginianus* and *L. glasgowi* each have the *Laelaps* crossed out and *Atricholaelaps* written in Ewing's handwriting so there is no doubt that Ewing erected the genus to include these species.

Ewing long realized that *glasgowi* and *virginianus* are conspecific and recently published a note to that effect. (1947).

After having studied the types and after having seen abundant material from all parts of the United States and a great many hosts, I am convinced that *L. californicus* is also a synonym of *L. glasgowi.* Under the description of *L. glasgowi* Ewing states that it is related to *californicus* but lacks the tooth-like spine on coxa II. As already mentioned, this spine is a family character and the type of *L. glasgowi* also has it, although it is very difficult to find because of the way the specimen is mounted. *Laelaps californicus* has page priority over *Laelaps glasgowi* and ordinarily *L. californicus* would be chosen as the proper name for this mite. But article 28 of the International Rules of Zoological Nomenclature provides that when two or more species are united to form a single one, if the names are of the same date, that selected by the first reviser shall stand. The accompanying recommendation that, "Other things being equal, that name is to be preferred which stands first in the publication (page precedence)," is not adopted since *L. glasgowi* has been used so frequently in the literature and *ad libitum* among contemporary American acarologists that there will be much less confusion if the name is retained.

Hosts and localities for the above three specimens are as follows:

L. californicus; Topaz, California, host unknown.

L. glasgowi; Urbana, Illinois, host, "wild rat."

L. virginianus; East Falls Church, Virginia, host, "wild mouse."

The above three types are shown on Plate VII of this paper.

The deutonymph, male and female of *Hypoaspis cricetophilus* were fully described and well illustrated by Vitzthum (1930). The similarity of this species to *H. glasgowi* is so striking that I am forced to consider it a synonym. However, a a few comments are necessary. In the deutonymph Vitzthum finds that the dorsal plate is emarginate on each side, varying from hardly noticeable to indentations so deep as almost to divide the plate. This condition has not been observed in the deu-

TABLE I.

Measurements	Peromyscus				Blarina				Didelphys				Sigmodon				Pinetomys			
	n	x	s	t	n	x	s	t	n	x	s	t	n	x	s	t	n	x	s	t
D–L	61	44.2	3.07		10	46.1	1.95	1.88	7	49.0	1.92	3.99	20	44.6	1.57	.54	15	45.4	1.64	1.41
D–W	61	29.3	2.32		7	30.6	2.57	1.29	6	32.5	1.12	3.10	20	29.3	1.17	.02	14	31.9	1.81	3.65
S–L	61	6.5	.37		6	6.7	1.48	.28	5	6.6	.2	.76	20	6.1	.37	4.54	12	7.1	.26	5.07
S–W_1	61	9.7	.60		6	10.0	.41	.99	5	10.1	.2	1.28	20	9.9	.15	1.39	14	9.7	.36	.47
S–W_2	60	13.3	.74		6	13.9	.67	.61	5	14	.71	2.06	20	13.3	.31	.26	13	13.4	.43	.65
GV–L	59	20.5	1.51		6	20.6	.84	.19	4	22.8	1.15	2.91	20	20.2	.47	.81	15	21.3	1.11	2.02
GV–W	60	8.6	.79		6	9.0	.48	1.05	5	9	0	.10	20	8.5	.41	.77	14	9.5	.36	3.77
A–L	53	5.7	.71		9	6.1	.51	1.24	6	6.4	.14	2.25	20	6.5	.23	4.43	15	5.9	.35	1.04
A–W	58	7.8	.66		8	8.5	.56	3.09	6	8.8	.25	3.62	20	7.7	.42	.56	14	8.3	.43	3.14
A–GV	55	4.7	1.23		9	4.1	1.35	1.18	5	4.5	1.14	.26	20	5.7	2.05	3.64	15	4.1	1.2	3.99
L–F	56	37.0	8.98		8	39.4	2.31	2.27	4	39.8	1.79	1.90	20	37.9	1.12	1.38	14	37.5	1.40	.60
L–H	56	43.2	2.82		8	45.4	2.83	1.99	4	46.8	2.67	2.39	20	43.5	1.73	.37	14	45.5	1.47	2.84
FT–L	56	9.6	2.63		8	10.1	.60	1.63	6	10.3	.55	2.01	20	9.5	.30	.26	14	9.6	.39	.09
FT–W	55	2.4	.15		8	2.5	.07	.63	6	2.5	0	.37	20	2.5	0	2.16	14	2.5	.45	.55
	Cynomys				Microtis				Oryzomys				Napeozapus				Marmota			
D–L	9	48.0	1.54	3.60	23	47.0	2.30	3.93	8	54.7	1.09	9.44	20	39.4	2.88	6.17	30	51.2	1.32	11.75
D–W	9	30.2	1.47	1.04	22	31.1	1.43	3.26	7	34.5	1.54	5.36	16	23.8	1.74	8.11	26	29.8	1.00	.94
S–L	8	6.5	.03	.40	19	6.7	.33	1.26	7	7.7	.25	2.56	8	6.0	.32	4.09	22	6.5	.33	.56
S–W_1	7	10.4	.23	2.63	17	10.4	.34	3.98	7	11.1	.54	5.46	7	8.9	.35	3.81	21	11.2	.33	10.18
S–W_2	7	13.9	.44	1.99	15	14.2	.63	4.52	7	15.4	.42	7.44	7	12.2	.75	3.56	20	15.1	.72	9.59
GV–L	9	21.5	.71	1.97	21	22.3	.78	5.23	8	4.5	.88	7.98	13	16.7	.61	8.70	23	21.8	1.20	3.72
GV–W	7	8.1	.27	1.73	20	9.2	.72	2.91	8	10.8	.43	4.07	4	7.5	.61	2.75	17	7.9	.42	3.41
A–L	5	6.2	.24	1.39	17	6.1	.29	2.18	7	7.1	.42	4.75	6	6.2	.23	1.59	24	7.4	.48	10.13
A–W	6	8.2	.25	1.81	17	8.4	.42	3.72	7	8.9	.62	4.42	5	7.3	.28	1.49	24	8.8	.40	7.15
A–GV	8	7.4	1.98	5.37	17	4.7	2.32	.16	7	5.0	.80	.72	11	5.0	.93	.88	24	8.9	1.60	12.60
L–F	7	41.9	2.12	4.30	23	39.0	1.49	3.18	7	55.1	1.78	10.68	12	27.4	1.32	11.27	15	42.3	1.38	6.90
L–H	8	45.6	1.65	7.33	22	46.3	1.80	4.65	8	48.9	1.27	11.47	15	33.4	1.54	12.80	13	48	1.62	5.81
FT–L	8	11.6	.46	6.36	22	10.0	.36	2.04	8	12.6	.33	9.94	18	7.1	.22	12.34	21	11.0	.55	2.19
FT–W	8	2.4	.16	1.19	22	2.6	.28	3.42	8	2.6	.37	.16	16	2.4	.83	.03	21	2.7	.21	5.41

tonymphs that I have seen of *H. glasgowi* but, nevertheless, I would not consider this of sufficient importance to justify a separate species, especially since the emarginations are not uniform. On page 420, Vitzthum stated that the pilus dentilis of the female is not laterally produced and therefore the species cannot be placed in *Haemolaelaps*. It does not seem probable to me that two species can agree so closely in all other respects but fail in this one character. It seems more likely that the pilus dentilis in the process of mounting became aligned with the chela, a thing that could easily and in fact frequently does occur. Under such circumstances it is difficult to determine the true nature of the pilus dentilis.

That the chelae were not clearly visible to Vitzthum may be surmised from his brief statements concerning them, stating only that both digiti are dentate, and from the fact that he did not illustrate them, it being his general policy to do so. Vitzthum also was not able to clearly distinguish the epistome of either the female or the male. It appeared to be, he reported, a simple, smooth arch.

In all other respects the three forms of *H. cricetophilus* agree so closely with *H. glasgowi* that I feel obliged to consider them as identical.

The species was found in North China in the nest of the hamster, *Phodopus bedfordiae* (Thomas).

Through the kindness of Dr. Harold M. Hefley I was able to see the type and paratypes of *Laelaps stegemani*. They agreed very closely with *H. glasgowi* and there can be no doubt that they are the same species. *L. stegemani* was taken from *Mephitis nigra,* the common skunk, in New York state.

Haemolaelaps scalopi Keegan, is adequately illustrated and described and agrees very closely with *H. glasgowi*. Through the courtesy of Dr. E. W. Baker I was able to study the type and found that it actually has seven pairs of ventral setae instead of five as stated by Keegan. This dissolved what might have been considered a worthy differentiating character and I have been obliged to make it a synonym of *H. glasgowi*.

Atricholaelaps sigmodoni was erected for the common laelaptine ectoparasite of cotton rats. Differences between it and *Haemolaelaps glasgowi* from other hosts proved, after an examination of many slides, to be of no specific value.

Atricholaelaps strandtmanni Fox, was described from a single specimen taken from a mouse or rat in Puerto Rico. Fox stated that it is similar to *H. megaventralis* in having a dorsal plate that covers most of the dorsum but this is a variable character and is true of many specimens of *H. glasgowi*. Unfortunately there is no drawing or description of the pilus dentilis. The fact that the genitoventral plate seems longer than in most specimens of *H. glasgowi* does not mean much, the distance from the anal to the genitoventral is quite variable. There is nothing in the description or the illustration to distinguish it from *H. glasgowi,* and I am therefore obliged to consider it a synonym.

Species Incorrectly Placed in *Haemolaelaps*

Atricholaelaps clippertonensis of Wharton (1941) properly belongs to *Hypoaspis sensu latus*. The following characters differentiate it from *Haemolaelaps:* the digitus mobilis is smaller than the digitus fixus, the digitus fixus has many teeth, the sternal plate is much longer than wide, and the male chelae are distinctly shear-like.

Likewise I do not believe that *Ischnolaelaps alexandrini* Fox (1946) is a *Haemo-*

laelaps. The female chelae are different, the sternal plate is longer than broad and the posterior setae are flattened. The drawing and description indicate that it is a *Hypoaspis sensu latus*.

CLASSIFIED LIST OF HOSTS

AVES

Strigiformes

Strigidae
- *Spectyto cunicularia* ..... *H. glasgowi*

Piciformes

Picidae
- *Ceophloeus pileatus* ..... *H. megaventralis*
- *Centurus carolinus* ..... *H. megaventralis*
- *Melanerpes erythrocephalus* ..... *H. megaventralis*
- *Syphrapicus varius* ..... *H. megaventralis*
- *Dryobates villosus* ..... *H. glasgowi*
- *Dryobates pubescens* ..... *H. megaventralis*

Passeriformes

Hirundinidae
- *Iridoprocne bicolor* ..... *H. megaventralis*
- *Riparia riparia* ..... *H. glasgowi*
- *Stelgidopteryx ruficollis* ..... *H. glasgowi*
- *Petrochelidon pyrrhonota* ..... *H. megaventralis*

Laniidae
- *Lanius ludovicianus* ..... *H. glasgowi*

Sturnidae
- *Sturnus vulgaris* ..... *H. megaventralis*
- *Passer domesticus* ..... *H. megaventralis*

Icteridae
- *Euphagus sp.* (Blackbird) ..... *H. megaventralis*

Fringillidae
- *Pipilo erythrophthalmus* ..... *H. glasgowi*
- *Melospiza melodia* (Rusty song sparrow) ..... *H. glasgowi*

MAMMALIA

Marsupalia

Didelphidae
- *Didelphis virginiana* ..... *H. glasgowi*

Insectivora

Talpidae
- *Scalopus aquaticus* ..... *H. glasgowi*
- *Scapanus townsendi* ..... *H. glasgowi*
- *Scapanus latimanus* ..... *H. glasgowi*

Soricidae
- *Sorex fumeus* ..... *H. glasgowi*
- *Sorex vagrans* ..... *H. glasgowi*
- *Cryptotis parva* ..... *H. glasgowi*
- *Blarina brevicauda* ..... *H. glasgowi*

Chiroptera

Vespertilionidae
- *Myotis griscens* ..... *H. glasgowi*

Carnivora

Procyonidae
- *Procyon lotor* ..... *H. glasgowi*

MUSTELIDAE
Mustela sp. (weasel) ..... *H. glasgowi*
Mephitis elongatum ..... *H. glasgowi*
Mephitis nigra ..... *H. glasgowi*
CANIDAE
Urocyon cinereoargentatus ..... *H. glasgowi*
FELIDAE
Felis catus ..... *H. megaventralis*

RODENTIA

SCIURIDAE
Marmota monax ..... *H. glasgowi*
Otospermophilus grammurus ..... *H. glasgowi*
Citellus columbianus ..... *H. glasgowi*
Citellus armatus ..... *H. glasgowi*
Citellus beechyi ..... *H. glasgowi*
Citellus mollis ..... *H. glasgowi*
Citellus tridecemlineatus ..... *H. glasgowi*
Citellus mexicanus ..... *H. glasgowi*
Ammospermophilus leucurus ..... *H. glasgowi*
Cynomys ludovicianus ..... *H. glasgowi*
Cynomys gunnisoni ..... *H. glasgowi*
Eutamias sp. ..... *H. glasgowi*
Tamias striatus ..... *H. glasgowi*
Sciurus hudsonicus ..... *H. glasgowi*
Sciurus douglasi ..... *H. glasgowi*
Sciurus carolinensi ..... *H. glasgowi*
H. megaventralis
Sciurus niger ..... *H. glasgowi*
H. megaventralis
Sciurus sp. (Alaska Squirrel) ..... *H. glasgowi*
Glaucomys volans ..... *H. megaventralis*
GEOMYIDAE
Thomomys bottae ..... ***H. geomys***
Thomomys bulbivorus ..... *H. geomys*
Geomys tuza ..... *H. geomys*
Geomys floridanus ..... *H. geomys*
Geomys cumberlandicus ..... *H. geomys*
Geomys bursarius ..... *H. geomys*
Geomys lutescens ..... *H. geomys*
Geomys personatus ..... *H. geomys*
Cratogeomys castanops ..... *H. geomys*
HETEROMYIDAE
Perognathus californicus ..... *H. glasgowi*
Perognathus hispidus ..... *H. glasgowi*
Dipodomys ordii ..... *H. glasgowi*
CRICETIDAE
Onychomys leucogaster ..... *H. glasgowi*
Reithrodontomys humilis ..... *H. glasgowi*
Baiomys taylori ..... *H. glasgowi*
Peromyscus sp. (White-footed mouse) ..... *H. glasgowi*
H. geomys
Peromyscus boylii ..... *H. glasgowi*
Peromyscus maniculatus ..... *H. glasgowi*
Peromyscus polionatus ..... *H. glasgowi*
Peromyscus leucopus ..... *H. glasgowi*
Peromyscus gossypinus ..... *H. glasgowi*
Peromyscus truei ..... *H. glasgowi*
Peromyscus nasutus ..... *H. megaventralis*
Peromyscus nuttalli ..... *H. glasgowi*
Peromyscus californicus ..... *H. glasgowi*
Oryzomys palustris ..... *H. glasgowi*

Sigmodon hispidus ..... *H. glasgowi*
H. megaventralis
Neotoma floridana ..... *H. glasgowi*
Neotoma pennsylvanica ..... *H. glasgowi*
Neotoma micropus ..... *H. glasgowi*
Neotoma cinerea ..... *H. glasgowi*
Neotoma sp. (Wood rat) ..... *H. glasgowi*
H. geomys
Synaptomys sp. ..... *H. glasgowi*
Phenacomys longicaudus ..... *H. glasgowi*
Evotomys gapperi ..... *H. glasgowi*
Microtus pennsylvanicus ..... *H. glasgowi*
Microtus breweri ..... *H. glasgowi*
Microtus montanus ..... *H. glasgowi*
Microtus nanus ..... *H. glasgowi*
Microtus californicus ..... *H. glasgowi*
Microtus ochrogaster ..... *H. glasgowi*
Microtus oregoni ..... *H. glasgowi*
Pitymys pinetorum ..... *H. glasgowi*
Neofiber alleni ..... *H. glasgowi*

MURIDAE

Mus musculus ..... *H. glasgowi*
H. megaventralis
Mus musculus (White Mouse) ..... *H. megaventralis*
Ratus norvegicus ..... *H. glasgowi*
H. megaventralis
H. morlani
Ratius rattus ..... *H. glasgowi*
H. megaventralis
H. morlani

ZAPODIDAE

Zapus hudsonicus ..... *H. glasgowi*
Napeozapus insignis ..... *H. glasgowi*

LEPORIDAE

Lepus californicus ..... *H. glasgowi*
Sylvilagus floridanus ..... *H. glasgowi*
Sylvilagus auduboni ..... *H. glasgowi*
Sylvilagus sp. ..... *H. glasgowi*

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A NOTE CONCERNING CERTAIN MICROPHALLID TREMATODES INFECTING SHORE BIRDS (*LIMOSA FEDOA* AND *CATOPTROPHORUS SEMIPALMATUS INORNATUS*) WITH DESCRIPTION OF A NEW SPECIES (*LEVINSENIELLA CHARADRIFORMIS*)

R. T. Young

Young (1938) described the life history of a trematode, tentatively identified as *Levinseniella cruzi,* from certain shore birds of the California coast but was unable at that time to experimentally transfer the worm from the intermediate (*Emerita analoga*), to the final hosts (*Limosa fedoa* and *Catoptrophorus semipalmatus inornatus*). Cable and Hunninen (1940, p. 153) have stated that the species might belong to either *Levinseniella* or *Spelotrema* as these genera are distinguished at present. Tentative identification was based on the classification of Travassos (1921) in which *Spelotrema* is given as a synonym of *Levinseniella,* but subsequent studies have shown that this was an error, which is corrected in the following account.

There are at least four microphallid species in these shore birds, a *Maritrema,* two species of *Spelotrema,* and a *Levinseniella.* The first of these has not been studied in detail, but its intermediate host is probably the sand flea (*Orchestoides*). One of the spelotremas is apparently *S. papillorobusta* of Rankin (1940), but material is too scanty to permit a final determination, while the other, which was tentatively identified as *Levinseniella cruzi* in the earlier paper (Young, 1938), closely resembles *S. nicolli* Cable and Hunninen, 1940, although differing from the latter in certain minor details. These concern chiefly egg size, form of vitellaria and proportions of oral and ventral suckers. The eggs of *S. nicolli* measure from 18–22 × 8–13 μ, while in the present specimens they average 25 × 12 μ, with a range between 21–28 × 8–13 μ. Cable and Hunninen described the vitellaria as so diffuse that a count of their lobes could not be made with certainty. As shown in Figure 3, there are 6–8 distinct lobes in the specimens at hand. However the lobes are fused at the center in a manner that suggests that their definition probably is largely a matter of technique. In *S. nicolli,* the acetabulum exceeds the oral sucker by 2 μ (58 vs. 56), while in the present specimens the reverse is true; again a difference of 2 μ (43 vs. 45). This criterion is not a satisfactory one, since in different specimens of the same species the relative proportions may be reversed. Nor is the extent of the intestinal ceca satisfactory. In some individuals these organs reach to or beyond the middle of the acetabulum, while in one at least they terminate much anterior thereto, the difference depending largely on the amount of contraction of the specimen. These differences do not warrant the separation of the present form from *S. nicolli,* since in all other respects the two are in agreement.

The presence of all four of the foregoing species in shore birds which have recently fed on *Emerita* and of metacercariae excysting in the stomachs of the birds is suggestive of the source of infection, but does not show which of the parasites is derived from this source, or whether more than one is so derived. Furthermore, as noted in the previous paper (Young, 1938), it is possible to obtain a temporary infection of fish by feeding them infected *Emerita.*

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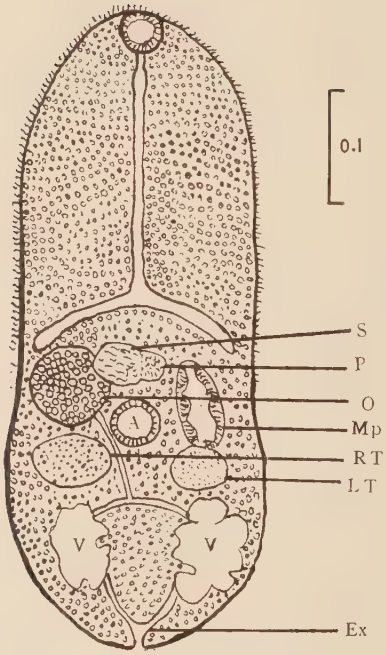

Fig. 1.

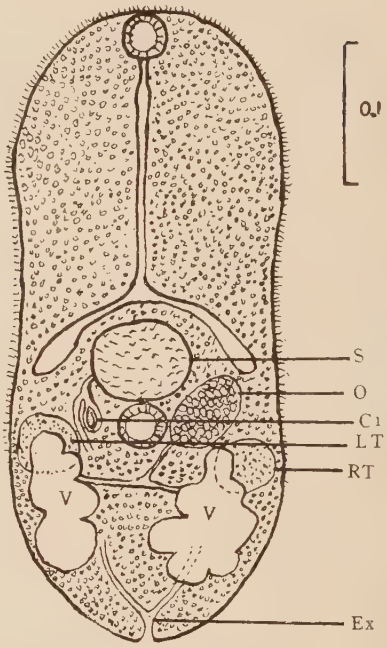

Fig. 3.

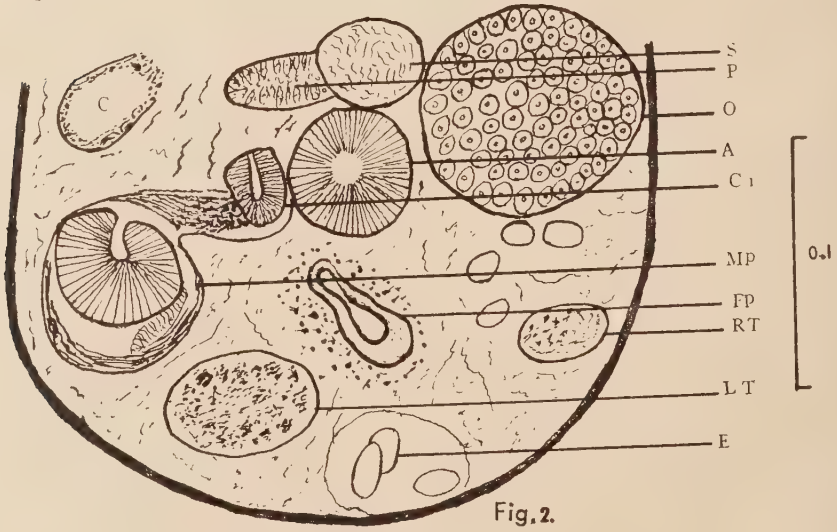

Fig. 2.

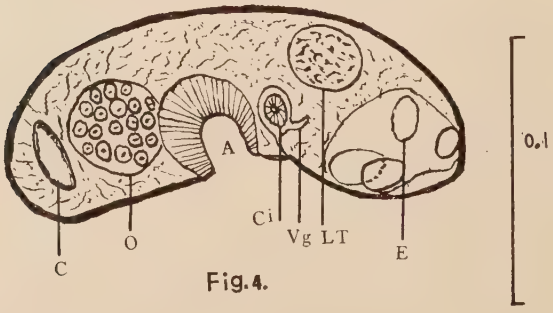

Fig. 4.

Conclusive feeding experiments with the shore birds would necessitate collecting young specimens from inland nesting grounds where they had had no opportunity for previous infection. This has not been possible. The writer was fortunate therefore in securing a captive specimen of the stone curlew (*Burhinus*) one of the charadriform birds, which include the godwit and willet.

Prior to experimental use, this bird had been fed on raw meat and fish and had certainly had no recent opportunity at least to obtain sand crabs, and probably had never seen them before, as evidenced by its hesitation to eat them at first, although it soon learned to take them greedily. After several feedings of sand crabs from July 25 to August 15, 1940, the bird was killed on August 21 and was found to be well infected; many adult worms were found in the intestine, and the stomach contained numerous recently excysted specimens. These proved to be a *Spelotrema* apparently identical with the species (*S. nicolli*) in the godwit and willet. Previous attempts to infect domestic chickens with this parasite had been unsuccessful.

Certain differences in the life history of this species and of *S. nicolli* as related by Cable and Hunninen (1940), suggest that the two might not be identical. The cercariae of the latter infect the snail (*Bittium alternatum*), the metacercariae live in the blue crab (*Callinectes sapidus*), and the adult in the herring gull (*Larus argentatus*), while in the species at hand the corresponding hosts are the snail (*Olivella biplicata*), the sand crab (*Emerita analoga*), and several species of charadriform birds.

However, according to Rankin (1940), both *Spelotrema claviforme* and *S. excellens* have a similar wide host distribution so that divergence of hosts in this case may not be significant of a specific difference. In one respect (i.e. the relative size of oral and ventral suckers) the present specimens more nearly resemble *S. pygmaeum* than *S. nicolli*. In other respects however they are more like the latter, than the former species. Whether or not these two are distinct is, in the writer's opinion, questionable, as is also the status of *S. capellae* Yamaguti, 1939. These observations thus present another, but very similar, life history to that described by Cable and Hunninen (1940).

The *Levinseniella* found in the willet and godwit occurs throughout the gut, but mainly in the lower bowel. It does not agree with any species hitherto described to the author's knowledge. The differentiation of closely related species of trematodes is based, to a considerable degree, on size and proportions. Using these criteria, a comparison of the specimens from shore birds of California with those previously described shows marked differences. The ventral sucker is slightly larger than the oral sucker, whereas in other species the suckers are either equal in size, or the oral

FIG. 1. Whole mount of *Levinseniella charadriformis*, showing general features.
FIG. 2. Frontal section of same through acetabulum, showing details of genitalia.
FIG. 3. Whole mount of *Spelotrema nicolli*, showing general features.
FIG. 4. Cross section of same through genital atrium, showing details of genitalia.

LEGEND:

A—acetabulum
C—cecum
Ci—cirrus
E—eggs in uterus
Ex—excretory duct
Fp—female pocket
LT—left testis
Mp—male pocket
O—ovary
P—prostate
RT—right testis
S—seminal vesicle
V—vitellaria
Vg—vagina

exceeds the ventral. Both suckers are naked, as are the cirrus and the pockets in the genital atrium. Both suckers are also considerably smaller than in other species excepting *L. minuta,* which is far too small to be confused with the present one. The eggs are larger than those of *L. indica, L. howensis, L. minuta* and *L. pellucida,* although agreeing fairly well with those of other species.

There are other differences which will be apparent from the description which follows. All measurements (in μ) have been made on preserved material.

Levinseniella charadriformis

(Figs. 1, 2)

With the characters of the genus. Body slightly constricted at the middle, 600 long by 214 wide. Oral sucker slightly smaller than ventral (34 and 42 respectively). Pre-pharynx 36; pharynx diameter 19; esophagus length 134; ceca terminating anterior to ventral sucker, 101×12. Male copulatory sac much larger than latter, 79×62, its four pockets unarmed, as are both oral and ventral suckers. Cirrus diameter 15; seminal vesicle 44×38; testes approximately equal in size, the left (76×48) slightly posterior to the right (70×50). Ovary 60×50. Uterus partially overlapping the ovary and the male copulatory sac. Eggs numerous, 24×12.

There are still certain inconsistencies in the literature regarding *Spelotrema* and *Levinseniella.* The species *cruzi* and *howensis* are placed by Rankin (1939) in the latter genus. He stated: (p. 433) "*L. cruzi* . . . possesses the accessory papillae in the genital atrium characteristic of *Levinseniella* (and) . . . until further evidence is obtained (it) must remain as a valid species." This statement however is unsupported by Travassos' account and by his figure, which does *not* show the complicated genital atrium characteristic of *Levinseniella,* while his description merely says "atrium genital pequeno e pouco (small and slightly) musculoso."

One other species of *Levinseniella* "recognized" by Rankin "as valid," is, in the author's opinion, of doubtful status. In the description of *L. howensis* given by Johnston (1917) he merely mentioned "a voluminous cirrus-sac and pars prostatica, and the copulatory bursa is rather smaller than in the other species of the genus," while his figure more nearly resembles that of *Spelotrema* than of *Levinseniella.*

The accompanying illustrations show general features and certain details of both species discussed in this paper.

The author wishes to thank the San Diego Zoological Society for the use of a room in the research laboratory, and especially Dr. Arthur L. Kelly, director of the laboratory, for many courtesies extended in the course of this investigation.

SUMMARY

A new species of microphallid trematode (*Levinseniella charadriformis*) is described from California shore birds, and the life history of *Spelotrema nicolli* has been traced from the sand crab (*Emerita*) to the stone curlew (*Burhinus*). A brief discussion of the status of *Levinseniella cruzi* and *L. howensis* is included.

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PRENATAL INFECTION OF DOGS WITH ASCARIDS, *TOXOCARA CANIS* AND HOOKWORMS, *ANCYLOSTOMA CANINUM*

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INTRODUCTION

Prenatal infection with parasitic worms has received considerable attention since Fuijinami and Nakamura (1911) found *Schistosoma japonicum* in the fetus of a dog. Following this discovery, prenatal helminthiasis has been observed a number of times in natural infections, and has been demonstrated experimentally in the case of the dog ascarid *Belascaris marginata* = *Toxocara canis* (Fülleborn, 1921; Shillinger and Cram, 1923; and Augustine, 1927), and the dog hookworm, *Ancylostoma caninum* (Foster, 1932). The following is a brief account of findings in two cases of prenatal infection of pups with the ascarid, *Toxocara canis* and the hookworm, *Ancylostoma caninum.*

OBSERVATIONS

The first case involved a litter of 8 pups. The dam, a Doberman pinscher, on 2 occasions prior to mating, was treated to remove intestinal helminths. The animal was then confined in an enclosure from which the accumulated feces were removed at frequent intervals. Following parturition the mammary glands of the bitch were washed whenever the puppies suckled to insure cleanliness and thus prevent, in so far as possible, infection of the pups with helminth parasites. Four of the pups died 13 days after birth. On the assumption that death was a result of exposure to inclement weather, no autopsy was performed. Another puppy died at the age of 22 days, however, and, at autopsy, 22 young adult ascarids and 19 young adult hookworns were recovered from the small intestine. Fecal examination of one of the 3 remaining pups when the animals were 28 days old showed heavy infection with both ascarids and hookworms. In spite of therapeutic measures which were initiated to correct anemia and ameliorate other effects of the parasitism, another pup died on the 30th day after birth and the remaining 2 died the day following. On post mortem examination there were recovered from the animals in question 127, 72 and 92 *Toxocara canis,* respectively, and 70, 72 and 9 *Ancylostoma caninum,* respectively. In all 3 animals, rupture of the walls of the intestine and of the bile ducts had occurred and ascarids were observed actively migrating through the ruptures.

The second case involved a litter of 6 pups. In order to insure that the dam, a mongrel, was free of intestinal helminths she was subjected to anthelmintic medication on 5 occasions prior to mating. Fecal examinations made subsequent to the last treatment and continuing throughout the period of observation failed to reveal the presence of helminth eggs in the droppings at any time. Following mating, the bitch was confined in a cage which was cleaned daily and exercised on a clean concrete floor.

Sixty days after mating the bitch delivered 6 puppies, all apparently healthy.

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The pups were not allowed to come in contact with the floor at anytime, and the mammary glands of the bitch were kept clean by frequent washings. Fecal examinations by the smear technique were initiated when the puppies were 6 days old. In spite of precautions taken to prevent infection, hookworm eggs appeared in the feces on the 18th day. In order to ascertain the number and kind of worms harbored by the young animals, one puppy was killed for autopsy on the 20th day, and another on each of the 22nd, 23rd, 25th and 26th days. All harbored hookworms, *A. caninum,* the number per animal being 6, 11, 5, 5, and 18, respectively. The pups killed on the 23rd and the 26th days harbored ascarids, *T. canis,* the number being 2, and 3, respectively. The pups killed on the 20th, the 23rd, and the 26th days harbored, in addition to the parasites listed, 4, 3, and 3 tapeworms, *Dipylidium caninum,* respectively. Ascarid eggs were found in the feces of the remaining pup on the 27th day, and 3 days later it was treated to remove the worms harbored; 10 *A. caninum* and 1 *T. canis* were recovered from the feces following treatment.

DISCUSSION OF FINDINGS

The observations summarized in this paper support those of Fülleborn (1921), Shillinger and Cram (1923) and Augustine (1927) that prenatal infection of pups with ascarids can occur. The observations support also the experimental findings of Foster (1932) relative to prenatal infection of pups with the dog hookworm. In the cases herein reported, reasonable care was exercised to maintain sanitary conditions in the kennels in order to preclude infection of the pups with helminths during the suckling period. In view of the sanitary precautions observed and the large numbers of worms harbored by the young animals it does not seem reasonable to suppose that the worms harbored by them were all acquired by the bitches during the gestation periods, especially since the bitches were each treated to remove parasites before mating occurred, and since subsequent fecal examinations failed to reveal the presence of helminth eggs in their feces. It is postulated, therefore, that the infections of the bitches which contributed to the parasitism of the pups had been acquired prior to initiation of the gestation period, a *pregestation* infection. It is postulated that infection of the bitches by the parasites in question had been going on for some time prior to treatment, the infections occurring in successive waves of mild superinfections in much the same manner as in artificial inoculation of larvae to dogs undergoing immunization. It is considered that a number of the infective larvae acquired by the adult animals during the *pregestation* infections had succeeded in reaching the intestine and were removed by the anthelmintics administered. Many of them however, were temporarily immobilized in the somatic tissues by the resistance of the host. During the gestation period, when the fetuses were developing and the resistance of the dam was lowered by the debilitating effects of pregnancy, the temporarily immobilized larvae became activated and drifted through the maternal circulation to the fetal tissue. In this connection, it is interesting to note that Augustine mentioned a predilection of toxocarid larvae to fetal tissue. Due to the restraining effect of the maternal resistance conveyed to the fetuses, the larvae remained dormant. When, however, the puppies were born this restraint was removed and the larvae began to grow. The writer considers that the finding by Shillinger and Cram of encysted ascarid larvae in the heart and lungs of the female

dog involved in their experiment supports the hypothesis herein set forth. The experiments of Foster and Cort (1933) on the effect of diet on hookworm infection in dogs is also considered as further support of this hypothesis. In certain of the results presented by the investigators last named, it was shown that in the case of dogs maintained on a good diet and given infections of hookworm larvae, egg production of the worms quickly fell to a low level. When the host animals were subsequently placed on a deficient diet, without additional infection, the egg count increased, and it was considered that this increase was due to increased egg production by the adult worms remaining in the intestines of the host dogs. In light of the findings herein reported, it may be considered that certain of the hookworm larvae had been delayed in their migration during the period when the dogs were maintained on a good diet and resistance was, therefore, high. Under conditions of poor nutrition of the host and the resultant lowering of its resistance, these larvae may have been able to complete their migration and contribute to the increased egg production noted.

SUMMARY

Two instances of prenatal infection of puppies with the dog ascarid, *Toxocara canis* and the dog hookworm, *Ancylostoma caninum* are reported. On the basis of the observations summarized herein, it is considered possible that infections of these parasites acquired by the bitches prior to mating (pregestation infection) may have been responsible for the prenatal infections observed in the puppies.

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OLSSONIELLA CHIVOSCA N. SP. (TREMATODA: DICROCOELIIDAE) FROM THE WESTERN EVENING GROSBEAK*

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Western evening grosbeaks collected during the spring migrations of 1947 and 1948 in Corvallis, Oregon, were found to be heavily infected with a trematode inhabiting the bile passages of the liver. Nine birds were examined, 6 of which were infected with 4 to 42 parasites per bird.

Serial longitudinal and cross sections as well as whole mounts were prepared for anatomical study.

The drawings were made by placing whole mounts on a Bausch & Lomb triple-purpose projector. The images were reflected onto photographic paper which was then developed. The anatomical details were traced with India ink after the paper was dried. Then the silver deposit was removed with photographic bleach and the paper again dried. Further details were added free-hand following a study of the serial sections. The same technique was employed for figures 1 and 3 except that a compound microscope was used instead of the projector.

The type specimen deposited in the U. S. National Museum has been catalogued as U. S. N. M. Helm. Coll. 37087. Nine paratypes have been catalogued as No. 37088 in the same collection. Additional paratypes have been deposited in the invertebrate collections, Department of Zoology, Oregon State College.

In the description below the first measurement was that of the smallest of a structure in any of the 9 paratypes, next the largest of a structure of the 9 paratypes in the U. S. National Museum. The third measurement given in parenthesis was of the type form.

Olssoniella chivosca n. sp.

Host and Locality: Hesperiophona vespertina brooksi, Corvallis, Benton County, Oregon, U. S. A.

Site of Infection: Bile passages of the liver.

Description: Body length, 3.75–6.0 mm (type, 4.45); width at testicular region, 0.175–0.3 mm (type, 0.3). Diameters of ventral sucker, 0.120 × 0.240–0.25 × 0.29 mm (type, 0.25 × 0.28); diameters of oral sucker, 0.12 × 0.21–0.25 × 0.33 mm (type, 0.2 × 0.22). Testes, 0.15 × 0.18–0.24 × 0.33 mm (type, 0.21 × 0.27); distance between testes, 0.001–0.18 mm (type, 0.08). Distance between posterior testis and ovary, 0.001–0.08 mm (type, 0.045). Total length of vitellaria, left, 0.4–0.55 mm (type, 0.4), right, 0.43–0.55 mm (type, 0.5). Number of vitelline follicles, 9 on each side. Completely formed ova within uterus, 0.02 × 0.045–0.031 × 0.05 mm (type, 0.03 × 0.047). Ventral sucker wider than the body adjacent to it. Laurer's canal opens dorsally to the exterior; not evident on the type specimen, but observed on sectioned specimens. Follicles of the vitellaria wider than long and separated slightly from each other. Anterior follicles converge toward the midline. In certain specimens the posterior follicles likewise converge. Junction of the ceca dorsal to the genital pore. Life cycle unknown.

Taxonomic Discussion: Travassos (1944) established the genus *Olssoniella* with *O. olssoni* (Railliet, 1900) as type species. The genus was separated from *Lyperosomum* primarily on the structure of the vitellaria. The follicles of the vitellaria of *Lyperosomum* are large, few and indistinctly separated from each other, while in *Olssoniella* they are smaller, more numerous and more distinctly separated from each other. The two genera resemble each other in the

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inequality of size of the suckers and in the slightly oblique placement of the two testes. Travassos included 19 species in the genus *Olssoniella* although he has placed question marks after a number of them. The new trematode falls into the genus *Olssoniella* as described and figured by Travassos. It is the first species of this genus described in the United States or in the North American Continent. Furthermore the host bird is not closely related to any other bird from which a species of this genus has been taken.

The species *Olssoniella stunkardi* described by Pande (1939), *O. halcyonis* reported by Yamaguti (1941), *O. rara* (Travassos) and *O. chivosca* are anatomically similar forms. Travassos suggested that *O. stunkardi* and *O. halcyonis* may be identical. *O. chivosca* differs from the preceding two species in the size and arrangement of the vitelline follicles. Those of *O. chivosca* are lateral in part, but the anterior and posterior follicles converge and approach the midline of the body. The vitelline follicles of *O. stunkardi* and *O. halcyonis* are all lateral, approximately in the region of the intestinal ceca and are smaller and more distinct than those in the new species. A comparison of these structures in *O. rara* and *O. chivosca* indicated that the new species lies somewhere between the former two and *O. rara*. The vitelline follicles of *O. rara* are larger and overlapping; the acini are indistinct. The follicles are not confined to the lateral areas of the body. The follicles of *O. chivosca* are smaller and more distinct than in *O. rara*.

The cuticle of *O. rara* has large, conical papillae irregularly distributed over the body. The surface of *O. chivosca* is smooth. The ventral sucker of *O. rara* is as wide as the body; that of *O. chivosca* is distinctly wider than the body. In *O. chivosca* the junction of the ceca with the esophagus occurs dorsal to the genital pore, in *O. rara* the junction occurs anterior to the genital pore.

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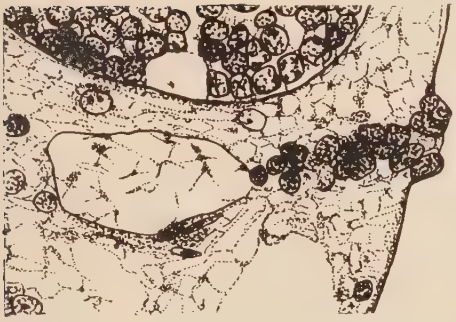

Fig. 1

Fig. 2

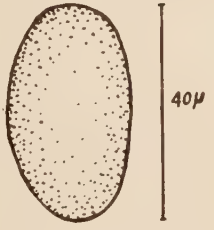

Fig. 3

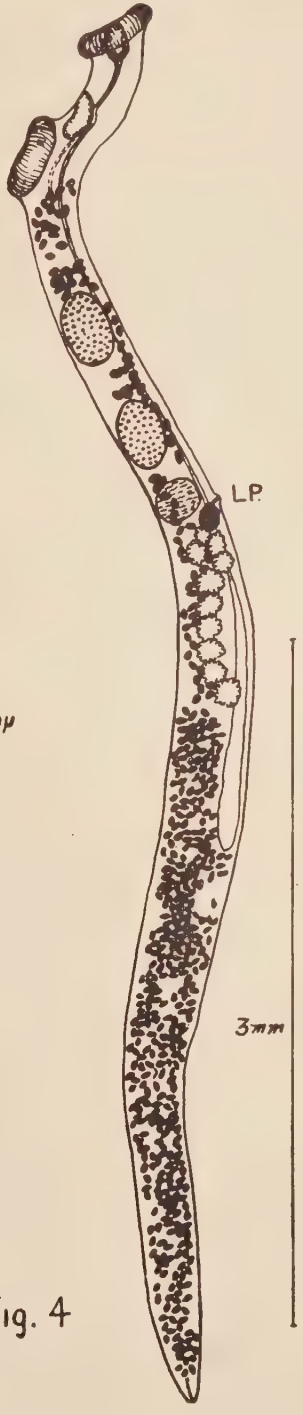

Fig. 4

PLATE I

FIG. 1. A section through the seminal receptacle, Laurer's canal and Laurer's pore. L. P. = Laurer's pore.

FIG. 2. Ventral view of fixed, stained and mounted specimen of *Olssoniella chivosca*.

FIG. 3. Ovum of *O. chivosca* taken from uterus of worm.

FIG. 4. Lateral view of left side of *O. chivosca*. L. P. = Laurer's pore.

TOXICITY OF SOME CHEMICAL COMPOUNDS TO CERCARIAE OF *SCHISTOSOMA MANSONI* *

FREDA GLASS SCHREIBER AND MAXWELL SCHUBERT

In the course of work on the effect of chemical compounds on *Schistosoma mansoni* infections in mice, experiments were carried out to test cercaricidal properties of some of these compounds.

Cercariae of *S. mansoni* freshly shed by infected snails, *Australorbis glabratus,* were collected in Great Bear Spring water. Such suspensions were diluted, if necessary, to contain about 30 to 50 cercariae per ml. and 2 ml. of the diluted suspension were added to each of a set of 5 ml. beakers. To each beaker an equal volume of a solution of the compound to be tested was added, mixing well at the same time, and the cercariae observed at intervals under a dissecting microscope. All these operations were carried out at room temperature, 22° to 28° C. The interval between the time of mixing and the time by which all the cercariae in a given beaker were found to be dead was recorded as the survival time of the cercariae in the presence of the chemical compound at its concentration in that beaker. Death of all cercariae was assumed to have occurred when they had all dropped to the bottom of the beaker and remained there with no visible motion for at least a half minute when observed under a dissecting microscope. Errors in survival time estimation are probably not greater than 20% of the survival time. In the accompanying table are listed the compounds tested. Because of the large error associated with the estimation of survival time no attempt is made to grade the compounds too finely as to toxicity. They are simply graded into three groups.

DISCUSSION

Effect of chemical substances on cercariae have been reported before. Krakower (1940) collected data on the effects of some inorganic salts and buffers on longevity of cercariae of *S. mansoni.* Kuntz and Stirewalt (1946) reported the effects of D.D.T. emulsions on cercariae of the same species. In this connection they pointed out that the emulsifying agent and xylene also have a potent effect in killing cercariae. McMullen and Ingalls (1947) studied the cercaricidal effects of copper and arsenic compounds as well as of a few organic compounds. These studies were mainly concerned with control of schistosomiasis. The results presented here are more of interest in studies that may be undertaken on the metabolism of cercariae. In section A of the table are listed the compounds most potent in killing cercariae. These substances could be expected to show considerable inhibition of cercarial metabolism at much lower concentrations. Most substances of this group fall into two classes, quinones and tertiary amines. That quinones should show such high

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TABLE I.—*Speed of action of some chemical compounds in killing cercariae of* Schistosoma mansoni

A. *All Cercariae Dead before 3 Minutes*

	mg. per liter
Sodium cyanide	500
1(3'4' Diethoxybenzyl) 6,7 diethoxy isoquinoline	500
Methyl dicyclohexylbutylamine hydrochloride	160
Methyl diγphenoxypropylamine hydrochloride	60
Dicyclohexyl-β-cyclohexylethylamine hydrochloride	250
Bis (βcyclohexylethyl) methylamine hydrochloride	500
Butylδ-cyclohexylbutylamine hydrochloride	60
Heptylβ-cyclohexylethylamine hydrochloride	120
1,3 Di(butylβphenylethylamino) propane hydrochloride	50
N, N'Hexamethylene bislauramidine dihydrochloride	500
Sodium2,6 dichlorbenzenoneindo 3'chlorophenol	50
Quinone	50
Tolu p quinone	50
Thymoquinone	500
p. Xyloquinone	50
1,2 Naphthoquinone	50
Hydroquinone	500
Balanites aegyptiaca Leaf Extract (1.5%)*	
Balanites aegyptiaca Fruit Extract (0.75%)	

B. *Cercariae Alive after 3 Minutes but all Dead before 30 Minutes*

Iodo-acetic acid	500
Gentisic acid	500
2,6 Dimethoxyquinone	50
Hydroquinone	50
Chloranil	50
2,5 Di(4 chlorphenoxy) 3,6 dichlorquinone	50
Thymoquinone	50
2 Methyl 1,4 naphthoquinone	50
2,4 Bis (p dimethylaminostyryl) quinoline methosulfate	500
8 Hydroxyquinoline 5 sulfonic acid	500
Sanguinarine	50
N-(βcyclohexylethyl) -piperidine hydrochloride	250
Rhodamine B	500
Dimethyldihydroresorcinol	500
1,2 Dibutylbenzylaminopropane hydrochloride	50
Phemerol	100
1 Dodecyl 1 methyl piperidinium iodide	500
ββ' Diisothiourea diethyl disulfide dihydrochloride	500
Methyl di(β cyclopentylethylamine) hydrochloride	120
Cyclohexyl β cyclohexylethylamine hydrochloride	250
Balanites aegyptiaca Leaf Extract (0.37%)	
Balanites aegyptiaca Fruit Extract (0.37%)	

Table I (cont'd)

C. *Most Cercariae still Alive after 30 Minutes*

	mg. per liter
Tri-chloracetic acid	500
3,5 Diido 4 pyridone N-acetic acid, diethanolamine salt	500
Sodium iodomethane sulfonate	500
Chloral hydrate	500
Trichloroacetamide	500
2-Iodobenzoyl glycine	500
Phenanthraquinone	500
α Naphthol benzein	50
Coerulignone	50
Catechol	50
Sodium naphthoquinone sulfonate	50
2 Methyl naphthoquinone	5
Potassium rhodizonate	50
Chloranilic acid	50
2,5 Di(4 tertiary butyl phenoxy) 3,6 dichlorquinone	50
2,5 Bisdimethylamino-p-benzoquinone	50
2-n-Amyl 6,7 dihydroxy 1,2,3,4 tetrahydroisoquinolin hydrochloride	50
6,7 Dihydroxy 1,2 dimethyl 3,4 dihydroisoquinolinium chloride	50
n-Methyl quinolone	500
Arecoline	500
Berberine hydrochloride	500
Dimethyldihydroresorcinol	50
Emetine	500
Quinine methochloride	500
Balanites aegyptiaca Bark Extract (0.37%)	

* Three grams of dried leaves, bark or dried fruit of *Balanites aegyptiaca* were ground to a fine powder and extracted with 100 cc. of water at room temperature for about 20 hours. This filtered extract is referred to as a 3% extract. It was serially diluted to give the concentrations indicated in the table.

toxicity to the actively metabolizing cercariae is not surprising since quinones are potent inhibitors of many enzymes. That a variety of tertiary amine salts should have an approximately equal toxicity is a little more surprising. The speed with

which compounds of these two classes at concentrations of 0.01% or less kills all cercariae is striking. Compounds of groups B and C in the table are far less effective in killing cercariae and serve mainly by way of contrast to emphasize the toxicity of the quinones and amines of Group A.

Some data are included on toxic effects of aqueous extracts of dried leaves, dried fruit and bark of the tree *Balanites aegyptiaca* because of the report of Archibald (1933) on their cercaricidal action. The extracts reported by Archibald appear to be more active than ours. This may be due to his use of the fresh fruit.

SUMMARY

The toxicity to cercariae of *Schistosoma mansoni* of a number of organic chemical compounds at concentrations of .05 to .005% is estimated. The most toxic compounds belong mainly to two classes, quinones and tertiary amines.

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PRELIMINARY OBSERVATIONS ON THE RELATION OF NUTRITION TO PEDICULOSIS OF RATS AND CHICKENS[1]

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Evidence accumulating in recent years suggests a relationship between nutrition of the host and the economy of its ectoparasites. The present author observed[3] a general trend toward intensified pediculosis on rats fed a ground wheat diet deficient in vitamin A and noted that the pediculosis could be somewhat reduced by the addition of carotene to this ration. György (1938) noted pediculosis on about 20 percent of rats kept on a riboflavin-free diet for eight to ten weeks and reported that pediculosis was practically eliminated by the therapeutic feeding of riboflavin. Searls and Snyder (1939) suggested that vitamin A was the main limiting factor in regulating the resistance of the rat to its lice. György and Eckardt (1940) complicated the problem by indicating that pediculosis was common on rats with certain cutaneous lesions similar to those produced when rats received a crude concentrate of vitamin B_6, lacking Factor 2 (pantothenic acid). György and co-workers (1942) also noted that pediculosis was one of the effects of toxicity in rats fed a synthetic diet incorporating crude linoleic acid with or without butter yellow. Kartman (1942, 1943) confirmed the earlier work on the relation of vitamin A to rat pediculosis and after reviewing the evidence suggested that vitamin A could not be considered the main limiting factor in this relationship.

The relation of host nutrition to other species of ectoparasites has also been studied, especially by De Meillon and co-workers (1946, 1947) in South Africa. These workers reported that egg laying of *Cimex lectularius* was drastically reduced and a large proportion of eggs were sterile when the bedbugs were fed on thiamin-deficient rats. When the tick, *Ornithodorus moubata,* was fed on thiamin-deficient rats there was a decrease in rate of growth and size of nymphs, a prolongation of the interval between each moult, and an additional moult before maturity. When these two parasites were fed on riboflavin-deficient rats, normal growth and reproduction took place in all cases.

An experiment with cattle lice was reported by Matthysse (1946) in which he suggested that vitamins A and D in the host apparently had no relation to the economy of these parasites.

MATERIALS AND METHODS

During the period November, 1947 to July, 1948 limited experiments were conducted to determine the comparative effects of certain vitamin deficiencies in

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[2] Present address: Parasitology Dept., Johns Hopkins University, School of Hygiene and Public Health, Baltimore.

[3] Unpublished observations, U. Wisconsin, Dept. Econ. Ent., 1937.

rats upon the rat louse, *Polyplax spinulosa* (Burm.). Experiments were also designed to determine whether there is a relation between malnutrition in chickens and the chicken body louse, *Eomenacanthus stramineus* (Nitzsch). The latter study was undertaken since there is a prevalent theory that, in the words of Barger and Card (1943), "When fowls are either qualitatively or quantitatively undernourished, they become more readily susceptible to the attacks of parasites . . . . than under conditions of optimal nutrition."

It should be noted that in both these experiments there exists a variable factor in the form of host activity. Such a complicating factor was not present in the experimental technique of De Meillon *et al,* cited above. The present work includes a study of host activity in chickens, but no such observations were made on the rats. The term "host activity," as used here, denotes that type of "grooming" ac-

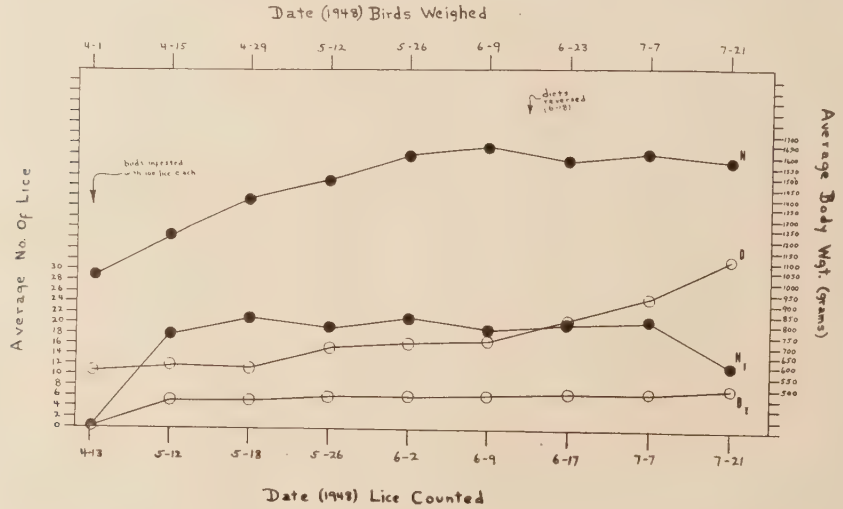

FIG. 1. Population trends of the chicken body louse, *Eomenacanthus stramineus* (Nitzsch.), on normal birds and birds suffering from severe malnutrition: N—body weights of birds on optimal diet; N_1—pediculosis on normal birds; D—body weights of birds on subminimal diet; D_1—pediculosis on deficient birds. Note change in trends after reversal of the diets.

tivity by which many animals and man attempt to rid themselves of external parasites.

For the rat experiments, locally bred albino rats were obtained as weanlings of both sexes between 26 and 28 days of age and averaging about 45 grams. All the animals were fed an identical basal ration free of all B-complex factors and vitamins A and D. The B vitamins in pure form were added to the ration or withheld as required by the plan of the experiment and vitamins A and D were fed to each animal twice a week in the form of cod liver oil or vitamin D alone as viosterol. The techniques followed the well established procedure for vitamin tests with albino rats and need not be detailed here.

The rats were housed in groups of five per cage and received food and water *ad libitum.* When typical avitaminoses were noted the rats were given an infestation of lice from reservoir hosts maintained as a source of these parasites. Control animals and those groups which failed to exhibit depletion symptoms were infested

at a time corresponding to the onset of deficiencies in the other groups. Some animals were given a later re-infestation with lice. The rats were maintained on deficient diets for from 60 to 75 days, unless dying before this time.

For the chicken experiments, white leghorns were raised from hatching under conditions which kept them ectoparasite-free. At eight weeks of age they were divided into two groups on the basis of body weight. The heavier group was placed on a normal diet while the lighter birds were fed a ration containing suboptimal or subminimal amounts of animal protein and required vitamins. Individual weights overlapped considerably as between the two groups, but the average weight of each group was different enough to allow for greater speed in producing the nutritional effects desired. The two groups probably did not differ significantly as regards

FIG. 2. Showing the type of debeaking to test the effect of host activity on the degree of pediculosis with the chicken body louse.

genetic or physiological features since all the birds came from the same highly inbred strain.

A preliminary experiment was based upon the production of a mild malnutrition in the birds, while a second test was based on severe malnutrition. All birds were infested with approximately equal numbers of body lice when weight differerences in the two groups appeared to be of significance as an index of relative state of health. Periodic observations on degree of pediculosis were based on aspirator samples of body lice obtained by means of the usual suction apparatus. A standardized procedure in securing the sample was that described by Nishida and Kartman (1948).

The debeaking of chickens is a regular practice among poultry farmers in the Hawaiian Islands and does not interfere with eating ability or production of meat

and eggs. Observations made during the course of frequent visits to poultry farms and on poultry in the University of Hawaii farm indicated that debeaking apparently affected the ability of the chicken to utilize its beak as a delousing instrument. Consequently, half the birds in each experimental group were debeaked to test the effect of host activity (see Fig. 2).

DISCUSSION AND SUMMARY

Table 1 summarizes data for tests involving seven different vitamin deficiencies in rats. It was observed that animals deficient in vitamin A, thiamin, riboflavin, and pantothenic acid maintained a mild pediculosis during the period after infestation or until death. In no case did the number of parasites equal or exceed the

TABLE 1.—*Relation of various avitaminoses to rat pediculosis*[1]

Rats fed ration lacking	No. rats	Sex	Avg. Body Weight (grams)			Infested with No. of lice at:		Pediculosis at termination of exp. or death of rats	Remarks
			Initial	Peak	Depletion	Depletion	12 to 31 days after depletion		
Vitamin A	5	3♂ 2♀	45.2	81.6	68.4	50	50	present	1 rat died prior to re-infestation
Thiamin (B_1)	9	7♂ 2♀	49.8	88.3	69.4	50	50	present	4 rats died prior to re-infestation
Riboflavin (B_2)	15	7♂ 8♀	51.8	101.5	86.6	50	25	present	Pediculosis eliminated after rats developed alopecia; 5 rats re-infested
Pyridoxine (B_6)	5	2♂ 3♀	46.2	146.8	106.6	50	25	absent	
Pantothenic Acid	11	4♂ 7♀	46.1	101.5	65.3	50	25	present	2 rats re-infested
Folic Acid	5	4♂ 1♀	36.0	205.6	....	50	25	absent	no avitaminosis noted
Choline	5	3♂ 2♀	45.8	178.8	....	50	25	absent	extreme variation in symptoms—no consistent avitaminosis noted
Controls (no deficiency)	15	5♂ 10♀	54.4	210.7	....	50	25	absent	5 rats re-infested

[1] Data for thiamin, riboflavin, pantothenic acid, and controls represent results of two separate experiments conducted under essentially identical conditions.

original number placed upon the host. Some counts of lice at the death of the hosts showed that the pediculosis consisted, on the average, of about one-third the original population. In the case of rats deficient in riboflavin the pediculosis was maintained only on those animals with normal fur whereas hosts exhibiting alopecia completely eliminated their parasites.

These data confirm former observations on vitamin A and riboflavin but do not appear to agree fully with the work on thiamin conducted with ectoparasites other than lice. The data also lend support to observations on the role of pantothenic acid in rat pediculosis and the relation of alopecia, as a symptom of aribo-flavinosis, to rat pediculosis.[4]

The present data further suggest that rats fed diets deficient in pyridoxine, folic

[4] Personal communication from Dr. Paul György.

TABLE 2.—*Relation of mild malnutrition in chickens to pediculosis and effect of debeaking*

Type diet	No. birds	Sex	Age at start	Avg. body wt. (gms) Initial	Avg. body wt. (gms) Final	Infested 11–20–47 with no. lice per bird[1]	Final louse count 3–8–48: avg. per bird[2]	Avg. no. lice on birds Not debeaked	Avg. no. lice on birds Debeaked	Remarks
Normal	10	10♂	8 wks.	451.5	1619.7	150	37.7	27.5	41.8	3 birds died prior to initial count and are not included in data
Suboptimal	10	10♂	8 wks.	351.1	1375.8	150	32.6	31.4	33.8	

[1] Number actually placed on each bird.
[2] Average number aspirated from birds by standardized method (see text).

acid, and choline, respectively, were able to rid themselves of an infestation with lice. Control rats on a complete ration also eliminated their parasites.

It should be noted that few eggs were found on animals in control groups and the other groups which eliminated their lice and that the parasites disappeared about ten to fifteen days after infestation in most cases. These observations differ from those of De Meillon who found a reduced egg production in bugs feeding on thiamin-deficient hosts, since the present study indicates a greater louse-egg production on thiamin-deficient rats than on control rats. It is suggested that the reported differences may be partially explained by host activity since in the present study control animals apparently rid themselves of lice rapidly enough to preclude deposition of large numbers of nits while deficient rats became less active, lost control of their infestation, and hence allowed a more extensive egg production to become evident. The DeMeillon studies were not concerned with the factor of host activity and thus pointed to thiamin deficiency as the limiting factor in egg production and egg viability of the parasites. The reproductive potential of lice living on deficient hosts has yet to be determined.

Tables 2 and 3 summarize data on the relation of mild and severe malnutrition in chickens to degree of pediculosis with the chicken body louse and also point out the effect of debeaking. Birds exhibiting a mild malnutrition showed no apparent differences in degree of pediculosis when compared with birds in robust health. On the other hand, birds showing a severe malnutrition exhibited a significantly lower degree of pediculosis than birds in good condition. This trend apparently

TABLE 3.—*Relation of severe malnutrition in chickens to pediculosis and effect of debeaking*

Type diet	No. birds	Sex	Age at start	Avg. body wt. (gms) Initial	Avg. body wt. (gms) Final	Infested 4–13–48 with no. lice per bird[1]	Final louse count 6–17–48: avg. per bird[2]	Avg. no. lice on birds Not debeaked	Avg. no. lice on birds Debeaked	Remarks
Normal	14	8♂ 6♀	8 wks.	512.1	1642.9	100	20.2	6.9	33.6	
Subminimal	14	6♂ 8♀	8 wks.	412.7	732.4	100	6.9	4.8	12.0	7 birds died prior to initial count and are not included in data

[1] See table 2.
[2] See table 2.

TABLE 4.—*Effect of reversal of diet on chicken pediculosis*

Type of diet		No. birds	Sex	Avg. body weight (grams)		Avg. no. lice per bird[1]		Remarks
Original	Final			When diets reversed	Final	When diets reversed	Final	
Normal	Subminimal	8	4♂ 4♀	1626.0	1594.0	22.9	11.3	On subminimal diet for 34 days
Subminimal	Normal	4	4♀	798.8	1086.8	4.8	6.5	On normal diet for 34 days

[1] Average number aspirated from birds.

obtained from about one month subsequent to the initial infestation until the termination of observations thirty-eight days later (see Fig. 1). The diets were then reversed, as between the two groups of birds, and a tendency toward decreased pediculosis on the normal birds and increased pediculosis on the deficient birds became obvious within thirty-four days. The normal birds on a deficient diet seemed to lose their lice more rapidly than the rate of increase of lice on the deficient birds feeding on a normal diet (see Table 4 and Fig. 1).

Birds on a normal diet exhibited larger and more extensive louse egg masses than birds suffering from severe malnutrition. This condition was in evidence throughout the experimental period and resulted in a higher count of immature lice on the former group except after the diets were reversed (see Table 5).

Observations on host activity suggest that debeaked birds on a normal ration have a significantly higher degree of pediculosis with the chicken body louse than their non-debeaked coop mates feeding on the same ration. This correlation does not appear to be as significant in birds suffering from either a mild or severe malnutrition, but the same trend is in evidence. It is interesting to note that the degree of pediculosis on normal birds with normal beaks was about the same as that for birds subjected to a severe malnutrition. This might indicate that the lice were reduced mechanically in the first case and by a lack of essential nutritive factors in the second case. When the diets were reversed the same relation of debeaking of the normal birds to degree of pediculosis was still in evidence after thirty-four days on the deficient diet. Aspirator samples gave an average of 8.5 lice for non-debeaked birds while debeaked chickens had an average of 18.0 lice.

Some objection might be raised in regard to the present comparison of the chicken body louse, a mallophagan having biting mouthparts, with a bloodsucking anopluran. On this point it is noted that frequent observations indicated that in a great number of larvae, nymphs, and adults of *Eomenacanthus stramineus* the midguts were filled with chicken blood. This finding occurred regularly throughout the experiments and confirms observations by Kotlán (1923) and Wilson (1933) on the blood-ingesting propensities of certain species of MALLOPHAGA.

TABLE 5.—*Average number of immature lice per chicken in aspirator samples at various times during experimental period*

Type diet	Date (1948) lice were counted							
	5–12	5–18	5–26	6–2	6–9	6–17*	7–7	7–21
Normal	3.5	5.3	5.2	5.9	4.5	5.3	4.1	2.8
Subminimal	1.0	0.7	1.7	1.6	1.0	1.0	1.2	2.0

* Diets reversed 6–18.

It has now been demonstrated that specific avitaminoses in the rat produce conditions favorable to pediculosis, but it cannot be concluded that certain, or all, of the vitamins implicated are the limiting factors in this relationship. Although it is evident that rat lice are able to live on hosts depleted of specific vitamins, there is a lack of experimental evidence whether the parasites carry on a normal life cycle under such conditions. The present experiments emphasize this point, since only a very mild pediculosis was encountered in those cases where lice maintained themselves on depleted hosts. This finding is in direct contrast to the original vitamin A experiments in which there was a tremendous increase of the louse population on depleted rat hosts. No explanation of this contradiction is advanced at this time.

The complexity of the problem is further exacerbated by the factor of host activity which may depend, in some cases, upon the presence of certain vitamins. It is known, for instance, that ariboflavinosis causes cutaneous changes which lead to a loss of sensory acuity in the rat. It may be presumed that any interference with normal host activity tends to favor pediculosis. Certain toxic conditions which inhibit grooming reflexes in rats favor the development of pediculosis even though the animals may be feeding on a ration containing optimal amounts of required vitamins and other food factors.

Data from the chicken experiments suggest that ectoparasitism with the chicken body louse is not necessarily an expression of malnutrition of the host. Indeed, the contrary appears to be true. At the same time, it is apparent that host activity may be a significant factor as regards the intensity of chicken pediculosis.

On the basis of the known facts, it may be generally concluded that host nutrition and host activity appear to be interrelated limiting conditions in an ectoparasite complex involving species of lice which are partially or completely hematophagous throughout their life cycle.

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CHEMOTHERAPEUTIC ACTIVITY OF CERTAIN 8-AMINOQUINOLINES, PARTICULARLY PENTAQUINE, IN EXPERIMENTAL CHAGAS' DISEASE

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The futility of treating Chagas' disease with agents active against the other trypanosomiases has long been recognized. Appreciable activity against *Trypanosoma cruzi* has been demonstrated by very few compounds, notably: the quinaldine derivative Bayer 7602 Ac (Mazza, Cossio and Zuccardi, 1937) and its close relatives (Goble, 1948), a tervalent arsenical Bayer 9736 As (Mazza, Basso and Basso, 1942), and certain phenathridinium products, S 1544 and S 1582 (Browning, Calver, Leckie and Walls, 1947).

Various limitations of these drugs have made a search for new agents against Chagas' disease desirable. In the course of screening many chemical groups in an effort to discover activity against *T. cruzi* several 8-aminoquinolines were tested.

TABLE 1.—*8-Aminoquinolines tested for activity against experimental Chagas' disease in mice.*

Survey No.	Chemical Name	Salt
SN 191	8-(dimethylaminoisobutylamino)-6-hydroxyquinoline[1]	monosulfate
SN 971	8-(1-methyl-4-diethylaminobutylamino)-6-methoxyquinoline[2]	monohydrochloride[2]
SN 1491	8-(nicotinylamino)-6-methoxyquinoline	base
SN 2026	8-(dibutylaminopropylamino)-6-methoxyquinoline	triphosphate
SN 5535	8-(diamylaminoethylamino)-6-methoxyquinoline	triphosphate
SN 7672	8-(diethylaminoethylthiopropylamino)-6-methoxyquinoline	monocitrate
SN 10994	8-(diethylaminopropylthiopropylamino)-6-methoxyquinoline	monocitrate
SN 11167	8-(diethylaminoethylthioethylamino)-6-methoxyquinoline	monocitrate
SN 13276	8-(isopropylaminoamylamino)-6-methoxyquinoline[4]	monophosphate

[1] "Certuna"
[2] "Pamaquin"
[3] "Plasmochin simplex"
[4] "Pentaquine"

Data from 3 screening tests which demonstrated activity in this group are presented below, together with information obtained in attempting to evaluate the most active product.

The compounds listed in Table 1, prepared in the laboratories of the Chemical Division of the Sterling-Winthrop Research Institute, were tested against *Trypanosoma cruzi* Chagas, 1909 in female Swiss mice. Three week old animals were infected by intraperitoneal injection of 0.3 ml. of overlay from 2 week old cultures prepared according to the method of Eleanor Johnson Tobie, as described by Hauschka, Saxe and Blair, (1947).

In screening tests medication was begun 4 days after infection and consisted, ordinarily, of 5 or 6 consecutive daily intraperitoneal injections of the drugs to be tested, in doses approximating the intravenous LD_{50} for mice. Usually these amounts could be given without evidence of toxicity although in some cases the dosage had to be reduced. On the other hand greater doses were sometimes well tolerated. In evaluation tests various periods of medication and dosages were used, as indicated in the tables.

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TABLE 2.—*Data from screening tests of certain 8-aminoquinolines against T. cruzi.*

Compound Number	Dose level mg/kg	Mean Survival Time (days)	Per cent surviving	
			Day last control died	60 days
Test No. 18 (20 mice per group)				
Untreated controls		20.0	all dead in 33 days	
SN 11167	20	20.6	0	0
SN 7672	20	25.6	10	5
SN 10994	40	21.8	30	20
Test No. 21 (20 mice per group)				
Untreated controls		16.9	all dead in 35 days	
SN 2026	60	28.6	30	20
Test No. 22 (10 mice per group)				
Untreated controls		10.7	all dead in 13 days	
SN 11167	40	10.3	10	0
SN 7672	40	11.1	0	0
SN 10994	60	13.5	40	0
SN 2026	60	10.5	20	0
SN 1491	80	11.5	10	0
SN 191	100	10.6	20	0
SN 971	15	13.2	40	0
	20	15.6	60	0
SN 13276	15	14.7	60	0
	30	25.3	100	10

Medication began in all cases four days after infection and continued through the 9th day in test 18 and through the 8th day in tests 21 and 22.

Table 2 shows the results of the screening tests on 8-aminoquinolines, which indicated that there was activity against *T. cruzi* in the group and that SN 13,276 (pentaquine) was the most active of the compounds tested. SN 5535 was screened at 60 and 30 mg/kg on test 23 and 24 respectively and showed no activity. It was not included in tables 3 and 4, which were primarily concerned with evaluation of pentaquine. All of the compounds listed in Table 2 were also tested for activity against *T. congolense;* SN 2026 and SN 13,276 against *T. brucei.* No chemotherapeutic effects were observed in the tests on either of the last two parasites.

Knowing pentaquine was active as an antimalarial when administered orally, this method of medication was included in the evaluation test summarized in Table 3. Its effectiveness on oral administration was demonstrated therein and its activity by this route was subsequently studied, using longer medication periods (Table 4).

Finally an attempt was made to study the action of pentaquine in experimental Chagas' disease in two dogs, beginning medication as soon after infection as any

TABLE 3.—*Data from evaluation test (No. 23) on pentaquine (SN 13276) in treatment of experimental Chagas' disease in mice.*

Dosage mg/kg	Mode of Administration	Medication Period (days)	Total Dose mg/kg	Mean Survival Time (days)	Per cent surviving	
					Day last control died	60 days
Unmedicated controls				15.2	all dead in 19 days	
53	oral	1 dose on day of infection	53	14.8	0	0
20	intraperitoneal	4th thru 14th	220	32.4	80	20
30	intraperitoneal	4th thru 14th	330	36.1	95	30
40	oral	4th thru 8th	200	38.7	80	35
40	intraperitoneal	4th thru 8th	200	46.4	95	60
40	oral	0 thru 8th	360	44.9	90	55
30	oral	4th thru 14th	330	46.4	90	60
30	intraperitoneal	1st thru 12th	360	53.5	80	75
20	intraperitoneal	1st thru 12th	240	56.3	95	90

parasites could be detected in the blood. A dosage regimen of 20 mg/kg/day was proposed based on the tolerance of mice to doses of 20 and 30 mg/kg for 12 and 18 days and the fact that no deaths were reported by Berliner and Butler (1946) in monkeys receiving 24 mg/kg for 15 days, although severe toxemia and abdominal cramping were observed.

Treatment at the dose level of 20 mg/kg (15 mg base), however, was found to be unsatisfactory. Both dogs showed severe diarrhea, beginning during the night following the first dose (given at 4:00 pm), and continuing to some extent until death. They were medicated (by capsule) four times. The day following the fourth dose one of the dogs was dead and the other in such poor condition that treatment was suspended. The following day the surviving dog was moribund and was sacrificed, autopsy revealing enteritis as well as ileal and ileocolic intussusception.

The demonstration of trypanocidal activity against *T. cruzi* among the 8-aminoquinolines is of interest from three aspects: 1) it shows a new parasiticidal attribute

TABLE 4.—*Data from evaluation test (No. 24) on pentaquine (SN 13276) administered orally in the treatment of experimental Chagas' disease in mice.*

Dosage mg/kg	Number of Doses	Total Dose mg/kg	Mean Survival Time (days)	Per cent surviving 60 days
Untreated controls			26.2	20
2.5	12	30	23.9	10
	18	45	34.8	40
5.0	12	60	36.1	40
	18	90	36.1	40
10.0	12	120	38.4	45
	18	180	43.0	55
20.0	12	240	48.0	75
	18	360	58.5	95
30.0	12	360	56.8	90
	18	540	56.0	90

The medication period for the 12 dose schedule was: 4th through 9th day and 11th through 16th day after infection. The 18 dose regimen included additional medication from the 18th through 23rd day.

of this chemical group; 2) it reveals a new chemical group in which to seek compounds active against *T. cruzi;* 3) it introduces an agent for the treatment of experimental Chagas' disease which is active on oral administration, all previously suggested compounds having been usable only parenterally.

The 8-aminoquinolines studied here represent, of course, only a very small number compared with the total number synthesized in connection with the Survey of Antimalarial Drugs (Schmidt, 1946). There is no reason to assume any parallelism in activity against malaria and Chagas' disease or that pentaquine is superior to any of its anti-malarial relatives which have never been tested in *T. cruzi* infections.

Whether pamaquin analogues will ever be clinically useful in American trypanosomiasis may be questioned on the basis of the known toxicity of the group (Alving *et al.,* 1948). The blood dyscrasias which occur in non-Caucasian patients under pamaquin therapy (Earle *et al.,* 1948) are not propitious signs in considering treatment of the ethnic groups inhabiting areas where Chagas' disease occurs.

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STUDIES ON *MANSONIA XANTHOGASTER* AND ITS RELATION TO FILARIASIS IN THE SOUTH PACIFIC[1]

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Wuchereria malayi is typically oriental in distribution (Craig and Faust, 1944) being endemic in Southern China, Indo-China, Malaya, Southern India and the East Indies where the generally accepted mosquito vectors belong to the genera *Mansonia, Anopheles, Culex,* and *Aëdes.* The presence of this species of *Wuchereria* in the South Pacific stimulated an interest in determining the potential vectors of this microfilaria.

Mansonia xanthogaster was thoroughly studied throughout the New Hebrides islands in view of fact that other species of this genus are known to be important intermediate hosts of this pathogenic microfilaria. No fully developmental infective stage larvae were reported in dissection studies conducted on the single representative of the genus *Mansonia.* Extensive studies conducted by Byrd and St. Amant failed to reveal any mosquito hosts responsible for transmission in the New Hebrides and no demonstrable vector was reported in over a year's survey (Byrd 1945). It was concluded that *W. malayi* existed as a non-transferable parasite in the blood stream of Tonkinese inhabitants imported to the islands of the South Pacific as laborers in the coconut and coffee plantations.

During the course of study, however, biological data were accumulated by Avis and Perry on *Mansonia xanthogaster,* the larva of which was reported to be unknown prior to 1945.

The aquatic stages were first discovered by the author during extensive surveys in swampy areas on Aore Island in the New Hebrides. They were subsequently found on Espiritu Santo in the New Hebrides, and this island represents the type locality for the larvae and pupae.

Studies on the life cycle were made and recorded to compare with the environmental habitats of species well known in the United States. Like the American representatives of this genus, the aquatic forms are peculiar in that the immature stages are found attached to submerged fleshy roots, stems and leaves of aquatic vegetation.

Only a single host plant was demonstrated; this being the soft rooted, dwarf *Pandanus,* growing in depths of one to three feet in heavily shaded, overgrown fresh water swamps. The ecological "niche" in which larvae and pupae were found

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varied but slightly from swamp to swamp, and the typical host plant was well represented along the margins of known breeding sites.

Extensive search of other likely hosts such as aquatic sedges, floating duckweed, or the numerous white water lilies, failed to reveal any attached aquatic forms. It is believed that the *Pandanus* represents a new host record for members of this medically important genus of mosquito.

Unlike laboratory rearings of such species as *M. perturbans* in southern United States, where larvae developed to adults in three months, and where some continued their development through the next year, *M. xanthogaster* did not exhibit any tendency to produce partial second broods as a result of delayed development of aquatic stages. Breeding was continuous throughout the year except where shallow swamps, dependent upon rainfall for maintenance, evaporated during the "dry" season.

Females from a series of 4 separate lots captured in the field deposited, in "rafts," an average of 58 pearl-grey ova when confined in the insectary. These ova turned black in eight hours and first instar larvae were noted in 72 hours.

The 4th instar larva is typically *Mansonia*-like, possessing a rather large head (Fig. 3) and long whip-like antennae. The siphon (Fig. 1) possesses characteristic saw-tooth projections to facilitate insertion into its host plant. Larvae collected in the field were induced to attach to roots of laboratory-reared *Pandanus* in water supplied from localities where the aquatic forms were collected.

The pupae are unremarkable in regards to chaetotaxy but possess conspicuously large, serrate-edged anal paddles (Fig. 4). The trumpets (Fig. 2) bear at their tips a pair of efficient forked barbs with numerous downward projecting leaflets. These forked structures are broken off at the time of emergence of adults. The pupal stage lasted 2–3 days. Upon detachment from their parent plant many of the pupae died as a result of their failure to reinsert satisfactorily their forked trumpets into the woody *Pandanus* plants. One specimen penetrated the soft rooted water lily, and it is felt that the pupae and larvae may be able to re-establish oxygen connections in other soft tissue plants once they are mechanically dislodged.

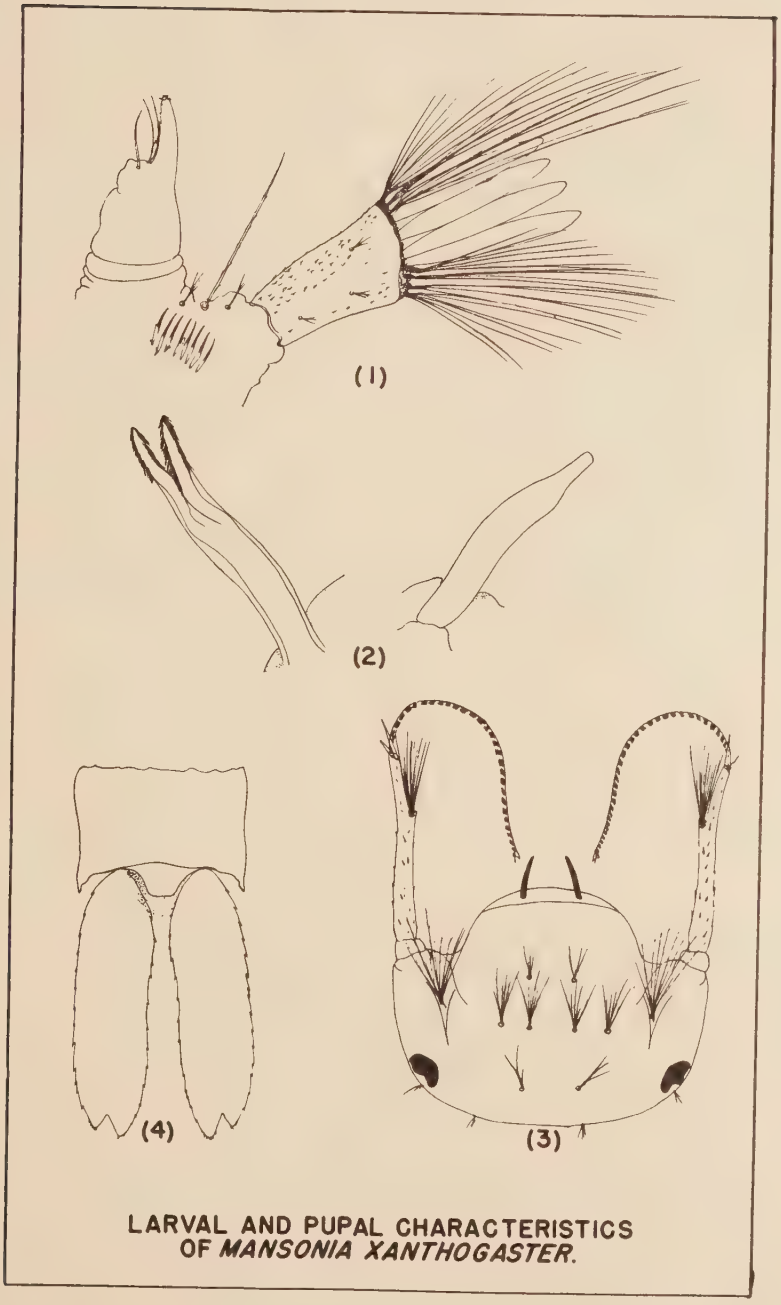
The period from egg to adult varied from 21–26 days.

Antennae: The antenna is longer than the width of the head and appears as though composed of two contrasting segments; a *proximal* and *distal* portion. The *proximal* portion has a stout appearance, resting upon a broad pedestal from the antero-lateral margins of the head. The antenna exhibits a slight outward curve, is moderately pigmented, beset with short, stout spines and terminated by two long non-pigmented spines. The antennal hair tuft is medially located and composed of 15–18 non-plumose hairs. The *distal* portion appears as a gradually tapering, non-pigmented, flexible filum terminated by a distinct spine and a rather indistinct short leaflet and hair. The medial margin does not have a distinct border.

Head: The head is broader than it is long. The capsule is pale brown or yellowish. The angles are smoothly rounded, sweeping up laterally to form adequate basal supports for the antennae. The small, pigmented eyes are located at the lateral angles of the head. The mouth brushes are prominent. The clypeal spines are long, stout, and yellow-orange in color.

Head hairs: Number 4: 3–4 single hairs. Number 5 and 6: 6–8 sparsely plumose single hairs. Number 14: 5–8 short single hairs. Number 7: consists of a tuft of 10–12 single, finely plumose hairs which arise from a single base which is inserted in the frontoclypeal plate.

Abdomen: Lateral comb of segment 8 consists of 7–8 long, stout, sharply pointed, smooth-surfaced scales. These are arranged in a straight row and are somewhat unequal in length. The anal segment is heavily encapsulated. The distal portion of the air-tube is attenuated with short, blunt saw-tooth projections along one border. The tip is terminated by 6–8 short spines arranged in a circle. The air tube is two times longer than wide, completely sclerotized and with 4 equal



LARVAL AND PUPAL CHARACTERISTICS
OF *MANSONIA XANTHOGASTER*.

length elongate anal gills as long as the segment. The ventral brush has 8 tufts of hairs each with 4–8 single long hairs. The dorsal brush has 3 tufts of hairs, each with 4–10 single long hairs.

SUMMARY AND CONCLUSIONS

(1) Prior to 1944 *Wuchereria malayi* was not known in the islands of the Solomons and the New Hebrides.

(2) *Mansonia xanthogaster* was carefully studied in view of the knowledge that members of the genus are responsible for the transmission of this microfilaria in Southern China, Indo-China, Malaya, Southern India and the East Indies.

(3) Extensive dissections of *M. xanthogaster* and other likely intermediate hosts failed to reveal any fully developmental infective stage larvae in the mosquitoes from these areas.

(4) *W. malayi* occurs as a non-transferable microfilaria in the native populations of the New Hebrides and possibly the lower Solomon islands and bears no military importance in view of the absence of suitable vectors.

(5) The larvae and pupae are reported for the first time with a new host plant likewise peculiar to these islands.

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TETRATHYRIDIUM LARVAE OF *MESOCESTOIDES* IN RODENTS IN CYPRUS

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Witenberg (1934), summarized the information on *Mesocestoides* and listed a number of intermediate hosts in which the *Tetrathyridium* larvae of this genus have been found. He also gave several isolated records of the size of infections encountered in individual animals, including one mentioned by Skrjabin and Schultz (1926) where 950 larvae were found in one mouse; there seems however to be little information on the usual number of larvae found in infested animals, or on the frequency with which infested animals occur in wild populations of the intermediate host, both important points in any consideration of the ecology of the parasite or its hosts.

During the course of an investigation into the ecology of *Rattus rattus* in Cyprus, 1271 rats were received from various places along the north coastal region of the island during the year April 1947 to April 1948; these rats were opened and their reproductive organs examined to determine details of the breeding season of this species. It was noticed that a number of these rats contained cestode larvae free in the peritoneal cavity. These larvae were identified by R. M. Gambles of the Cyprus Veterinary Service as *Tetrathyridium* larvae of *Mesocestoides* sp. *Mesocestoides lineatus* (Goeze) is a common tape-worm in dogs in Cyprus and occurs in the local fox, *Vulpes vulpes*. A note was made of the presence or absence of larvae in each rat examined, also of the approximate number of larvae in each infected animal. An accurate count of the number of larvae in every animal was impracticable and was not attempted; counts showed that it was possible to estimate the number of larvae to within 20%.

The number of larvae in individual rats varied from one to well over a thousand; the largest number counted was 950, but several animals were seen with heavier infestations; when such animals were opened the viscera and mesenteries were almost completely hidden by tetrathyridia. 47% of the infestations were of less than 50 larvae, though up to about 300 were not infrequently found; only 12% of the infected animals had heavier infestations (Table 1). There is a suggestion that

Table 1.—*Distribution of* Tetrathyridium *larvae in rats of different weights and sexes.*

No. of larvae	Body weight of rats, grams.											
	50 –	100 –	150 –	200 +	Total ♂♂	50 –	100 –	150 –	200 +	Total ♀♀	Total rats	%
< 10	5	8	9	11	33	4	10	19	8	41	74	18.3
< 50	1	8	28	25	62	6	11	29	8	54	116	28.7
100	1	4	17	21	43	6	10	21	9	46	89	22.0
250	1	2	8	22	33	1	9	23	10	43	76	18.8
500	0	4	2	8	14	0	4	12	7	23	37	9.2
1000	0	0	1	0	1	0	2	5	4	11	12	3.0
Total	8	26	65	87	186	17	46	109	46	218	404	100

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TABLE 2.—R. rattus *infested with* Tetrathyridium *larvae*.

	Weight g.	Rats with larvae ♂♂	♀♀	Total	Rats examined ♂♂	♀♀	Total	% infested ♂♂	♀♀	Total
	– 50	0	0	0	14	11	25			
	50 –	0	0	0	10	11	21			
	100 –	1	7	8	5	15	20			
	150 –	6	8	14	14	23	37			
	200 +	2	3	5	11	4	15			
19 Apr.–17 June	Total	9	18	27	54	64	118			
	– 50	0	0	0	1	0	1			
	50 –	0	0	0	5	3	8			
	100 –	2	2	4	14	7	21			
	150 –	2	7	9	11	11	22			
	200 +	3	2	5	6	3	9			
18 June–12 Aug.	Total	7	11	18	37	24	61			
	– 50	0	0	0	4	4	8			
	50 –	0	0	0	12	10	22			
	100 –	3	7	10	18	29	47			
	150 –	11	9	20	26	30	56			
	200 +	3	0	3	11	3	14			
13 Aug.–4 Nov.	Total	17	16	33	71	76	147			
	– 50	0	0	0	7	5	12			
	50 –	0	0	0	14	15	29			
	100 –	0	2	2	3	12	15			
	150 –	10	13	23	20	21	41			
	200 +	7	2	9	14	5	19			
5 Nov.–2 Dec.	Total	17	17	34	58	58	116			
	– 50	0	0	0	1	0	1			
	50 –	1	1	2	7	21	28			
	100 –	1	2	3	12	13	25			
	150 –	3	18	21	10	37	47			
	200 +	16	16	32	29	25	54			
3–31 Dec.	Total	21	37	58	59	96	155			
	– 50	0	0	0	6	2	8			
	50 –	5	5	10	23	28	51			
	100 –	5	8	13	15	28	43			
	150 –	7	18	25	19	33	52			
	200 +	17	8	25	26	15	41			
1–28 Jan. 1948	Total	34	39	73	89	106	195			
	– 50	0	0	0	3	0	3			
	50 –	2	5	7	10	26	36			
	100 –	7	14	21	20	32	52			
	150 –	7	20	27	16	39	55			
	200 +	10	2	12	18	4	22			
29 Jan.–25 Feb.	Total	26	41	67	67	101	168			
	– 50	0	0	0	1	1	2			
	50 –	0	4	4	10	12	22			
	100 –	3	3	6	25	27	52			
	150 –	7	8	15	14	16	30			
	200 +	10	4	14	19	9	28			
26 Feb.–25 Mar.	Total	20	19	39	69	65	134			
	– 50	0	0	0	0	0	0			
	50 –	0	1	1	7	9	16			
	100 –	4	8	12	24	26	50			
	150 –	17	17	34	27	33	60			
	200 +	21	14	35	31	20	51			
26 Mar.–23 Apr.	Total	42	40	82	89	88	177			
	– 50	0	0	0	37	23	60	0	0	0
	50 –	8	16	24	98	135	233	8.2	11.8	10.3
	100 –	26	53	79	136	189	325	19.1	28.1	24.3
	150 –	70	118	188	157	243	400	44.6	48.7	47.0
	200 +	89	51	140	165	88	253	54.0	58.0	55.2
19 April 1947–23 April 1948.	Total	193	238	431	593	678	1271	32.5	35.2	34.0

female rats may tend to have heavier infections than the males but the difference is not statistically significant; ($\chi^2 = 7.76$, for four degrees of freedom, the 500 and 1000 larvae classes being combined, $P = 0.1$).

The rats are grouped by weight in the tables; the body weight of a rat in the absence of a more convenient criterion is taken as an indication of the age of the animal. It is to be expected that the longer an animal lives the more chance it will have of becoming infected, and it will be seen (Tables 2 & 3) that the heavier the body-weight group the larger the percentage of infested rats in it. It might also be expected that the longer an animal lived the more larvae it would be likely to pick up, unless the presence of one lot of larvae inhibited the establishment of a second lot, but several rats were found with larvae of two distinct sizes indicating a second infection acquired some time after the first. If the figures for the number of larvae in males and females are examined separately (Table 1) there seems to be a significant association between body weight and number of larvae in the males, but in

TABLE 3.—*Rats infested with* Tetrathyridium *larvae from two different localities.*

Weight g.	Rats examined			Rats infested			% infested		
	♂♂	♀♀	Total	♂♂	♀♀	Total	♂♂	♀♀	Total
From Ayios Amvrosios									
−50	14	13	27	0	0	0	0	0	0
50−	49	66	115	7	12	19	14.3	18.4	16.5
100−	66	86	152	18	39	57	27.3	45.4	37.5
150−	83	163	246	46	102	148	55.4	62.5	60.1
200+	118	64	182	79	42	121	67.0	65.6	66.4
Total	330	392	722	150	195	345	45.4	49.7	47.8
From Karavas									
−50	14	4	18	0	0	0	0	0	0
50−	37	55	92	0	3	3	0	5.5	3.3
100−	52	80	132	5	10	15	9.6	12.5	11.4
150−	50	49	99	17	7	24	34.0	14.3	24.2
200+	29	14	43	4	3	7	13.8	21.4	16.3
Total	182	202	384	26	23	49	14.3	11.4	12.8

the females the number of larvae would seem to be randomly distributed in relation to body weight. For the purpose of calculating χ^2, the two body weight groups below 150 g. were combined, as were also the larval classes of 250 and above. For ♂♂ $\chi^2 = 18.93$ for 6 degrees of freedom $P = 0.01$; for ♀♀ $\chi^2 = 6.56$ for 6 degrees of freedom $P = 0.5$–0.3. It is possible that very heavy infections may cause a greater strain on the females' metabolism than on the males; were this so, heavily infected females would fall into a lower body-weight class than would those of the same age that were not parasitized and the relationship between age and size of infestation would be masked.

Table 2 shows the number of rats by weight and sex which were examined and those found infected at different times of year. It will be seen that young rats, those between 50 and 100 grams in weight, were found infected from December to March with one record for early April; it was at this time of year also that adult rats of both sexes were found containing tetrathyridia of two distinct sizes. This shows fairly conclusively that these parasites are acquired by the rats in the winter and spring months and so presumably it is at this time of year that the primary, or first intermediate host, some species of oribatid mite according to Soldatova (1944),

are active. The difference in the totals of infected rats in Tables 1 and 2 is due to the fact that for a few weeks, only the presence or absence of the tetrathyridia was noted and no attempt was made to estimate the number present.

Enough rats were received from two villages, Ayios Amvrosios and Karavas, to enable the infections in the two rat populations to be directly compared (Table 3). The two villages are situated 27 miles apart at the foot of the Northern Range about two miles from the sea. The surrounding country is mainly arable land thickly planted with carob and olive trees and is intersected with gullies. Karavas has a population of 2,100 and Ayios Amvrosios 1,700. The rats were mostly caught in the country round the villages. Although the two areas are superficially similar the proportion of infected rats in each is different. At Ayios Amvrosios 345 rats were infested out of a total of 722 examined or 48%; at Karavas only 49 out of 384 or 13% contained tetrathyridia. Thus *Mesocestoides* is by no means evenly distributed even over this small area. It is to be expected that the degree of infection in intermediate hosts would decrease with distance from the villages as the number of dogs would decrease and there would be fewer infected faeces and so infected mites to pass on the larvae; but in the neighbourhood of two similar villages where the dog population is high, the number of infested intermediate hosts should be similarly high.

TABLE 4.—*Spiny mice,* Acomys dimidiatus, *infested with* Tetrathyridium *larvae.*

No. examined			No. infested			% infested		
♂♂	♀♀	Total	♂♂	♀♀	Total	♂♂	♀♀	Total
161	149	310	21	15	36	13.0	10.0	11.6

A high density of tetrathyridia in an intermediate host such as was found at Ayios Amvrosios must indicate a high density of the other two hosts and the corresponding stages of *Mesocestoides* in them. There must have been a large heavily infected mite population since the tetrathyridia in the rats must have originated from it; similarly only a large dog population could have harbored an adult *Mesocestoides* population large enough to account for the number of eggs necessary to infect the mites; such a large adult *Mesocestoides* population would be expected since it would have been derived from the infections in the intermediate hosts. The size of the *Mesocestoides* population must be dependent on the density of its primary, intermediate and definitive hosts. If the populations of all three hosts are at their maximum density, *Mesocestoides* if introduced would spread through the three hosts and reach its maximum density; the upper limit being presumably determined by immunity or resistance acquired by the definitive host and impediments to the passage of the parasite from one host to another; it will be noticed that young rats are much less infected than old ones, but it is young rats which would be caught most easily by predators. A reduced density in any one of the three hosts would be reflected in the *Mesocestoides* population as a whole; a small mite population for example would inevitably cause a reduction in the infection in the intermediate host since fewer infested mites would be available to be eaten, this in turn would affect the numbers in the end host. The difference between the proportion of infected rats at Ayios Amvrosios and Karavas could be interpreted as being due to an uneven distribution of mites, the primary host; there is no evidence to suppose that there

is any marked difference in the density of dogs or rats in the two places; the fox population is probably not large enough to account for the very heavy infection at Ayios Amvrosios; the difference in the number of rats sent in reflects the activities of the two rat-catchers rather than any real difference in the densities of rats in the two places.

A small number of spiny mice, *Acomys dimidiatus* were examined. 36 out of 310 or 12% were infected. The number of larvae was usually less than 50 but one very heavy infestation was encountered. Spiny mice live in rocky ground usually away from villages; thus their infections would probably originate with foxes rather than dogs which would account for the low percentage of infected animals.

SUMMARY

1. 1271 rats, *Rattus rattus* from the north coastal district of Cyprus were examined and 345 were found to contain *Tetrathyridium* larvae of *Mesocestoides* free in the peritoneal cavity.

2. The number of larvae in infected rats varied from 1 to over 1000, up to 300 larvae were frequently found in individual rats.

3. The proportion of rats infected increased with the body weight of the rats. There is a suggestion that the longer a rat lives the more larvae it picks up.

4. Tetrathyridia were acquired during the months December to March which indicated that the primary host is active at this time of year.

5. 13% and 48% of the rats from two similar places, 27 miles apart, contained larvae, thus *Mesocestoides* is unevenly distributed over this small area. It is tentatively suggested that this may be due to uneven distribution of mites, the primary or first intermediate host.

6. 310 *Acomys dimidiatus* were examined and 36 or 12% were found infected.

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HAEMAPHYSALIS CENTROPI, A NEW SPECIES OF TICK FROM BIRDS IN THE FAR EAST[1]

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The new species here described was originally found among ticks collected by the United States of America Typhus Commission field party in the Myitkyina area of Upper Burma in 1945. Additional material from Palawan Island in the Philippines and from Selangor, Malaya has been found in the collections made by the Chicago Natural History Museum Philippine Zoological Expedition (1946–1947) and the U. S. Army "Chloromyce" Scrub Typhus Team (1948), respectively. The only known hosts are birds, and with but three exceptions all collections are from *Centropus* spp.

Haemaphysalis centropi n. sp.

Male (Fig. 1, A-F)

Body: Length from tips of palpi to posterior margin, 2.36[2] to 2.82; width, 1.35 to 1.68; average of 12 specimens, 2.57 by 1.53. Ovoid, widest at about the fourth coxae.

Capitulum: Length from tips of palpi to tips of cornua about 0.54, length of basis 0.21; width of basis 0.36. Basis punctate, widest anteriorly, posterior margin between the cornua nearly straight. Cornua moderate, sharp. Palpal article 2 very salient laterally and slightly longer than article 3. Posterior margin of article 3 nearly straight but in some specimens a very slight point at the posterior internal angle. In ventral view, the basis is about twice as broad as long, the posterior margin straight. Palpal article 2 usually with 6 broad hairs on the inner margin; article 3 with a short, medially directed spur.

Hypostome: Widest at about the middle, blunt, slightly notched. Corona large. Dentition 4/4 with trace of 5/5 near the base, with 6 to 8 large teeth in the principal files. Length about 0.28.

Scutum: Length from tips of scapulae to posterior margin, 2.07 to 2.40, average of 12 specimens 2.22. Punctations numerous, moderately large and rather evenly distributed. Lateral grooves prominent, beginning at the level of interval between coxae II an III and continuing across two festoons on each side. Cervical grooves moderate, deep anteriorly, concave externally. Festoons long, well marked and the intervals usually dark.

Legs: Coxa I with a short, blunt internal spur; II, III and IV each with a short broad spur. Trochanter I with a small ventral spur, others practically unarmed. Length of tarsus I, 0.57; metatarsus, 0.38. Length of tarsus IV, 0.48; metatarsus, 0.35. Tarsi I and IV each with a minute, terminal, ventral spur.

Spiracular plate: Elongate and without dorsal process, size about 0.42 by 0.28.

Genital aperture: Between coxae II.

Female (Fig. 1, G-L)

Body: Length, 2 unfed specimens, from tips of palpi to posterior margin, 2.88 and 3.0; width, 1.68 and 1.74. Suboval, widest at about the fourth coxae. Marginal grooves distinct, beginning at about the level of coxae II and continuing across two festoons on each side. Festoons about as wide as long, intervals between them dark.

Capitulum: Length from tips of palpi to tips of cornua, 0.54 to 0.63; length of basis 0.18 to 0.24; width of basis 0.45 to 0.54. Sides of basis nearly straight, mildly converging posteriorly; posterior margin concave. Cornua bluntly pointed and about as long as the width at the base. Porose areas oval, well separated, mildly depressed, their longer axes converging anteriorly.

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[1] From the Rocky Mountain Laboratory (Hamilton, Montana), National Institutes of Health.

[2] All measurements in millimeters.

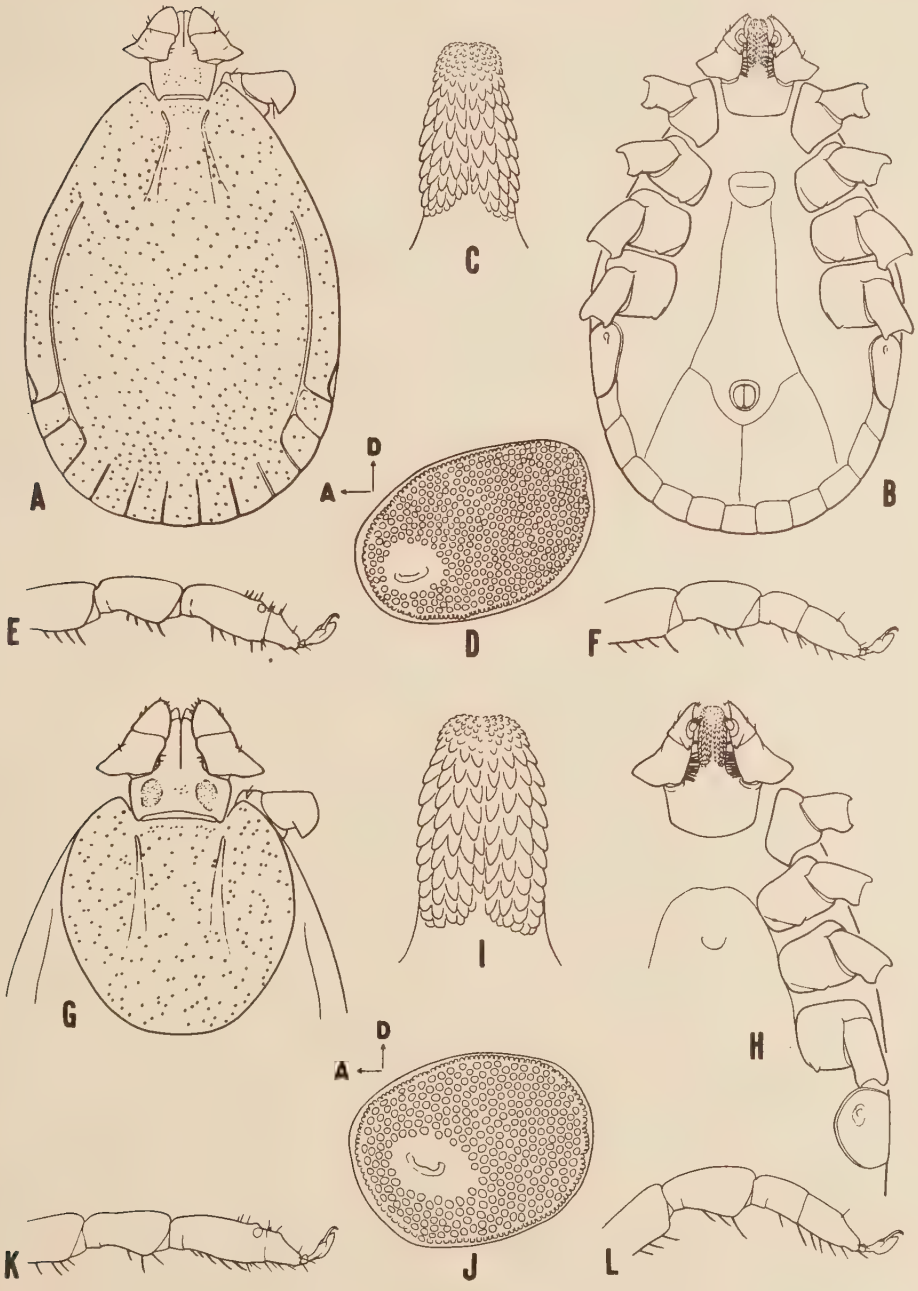

FIG. 1. *Haemaphysalis centropi* n. sp. A. Male capitulum and scutum, dorsum. B. Male capitulum and body, venter. C. Male hypostome. D. Male spiracular plate. E. Male metatarsus and tarsus, leg I. F. Male metatarsus and tarsus, leg IV. G. Female capitulum and scutum, dorsum. H. Female capitulum and coxae, venter. I. Female hypostome. J. Female spiracular plate. K. Female metatarsus and tarsus, leg I. L. Female metatarsus and tarsus, leg IV.

Palps greatly resemble those of the male, article 2 somewhat more salient laterally, and ventrally it is fringed with 8 to 10 broad hairs on the inner margin.

Hypostome: Broad, mildly notched apically. Corona moderate. Dentition usually 4/4 with principal denticles all of about equal size and 8 to 10 in each file; in some specimens the arrangement is 4/5 and in others 5/5. Length about 0.36.

Scutum: Nearly circular; measurements of 10 specimens range from 0.90 to 1.20 in length and from 0.90 to 1.20 in width. Cervical grooves sub-parallel, deeper anteriorly. Punctations moderately large and evenly distributed.

Legs: Coxae and trochanters essentially as in the male. Length of tarsus I, 0.62; metatarsus, 0.38. Length of tarsus IV, 0.55; metatarsus, 0.43. Terminal ventral spurs absent.

Spiracular plate: Sub-circular, size about 0.39 by 0.36.

Genital aperture: Opposite the interval between coxae II and III.

Holotype: Male, 22878, Myitkyina area of Upper Burma, from the lesser coucal, *Centropus bengalensis bengalensis* (Gmelin), May 6, 1945.

Allotype: Female, data as for holotype.

Paratypes: Myitkyina area of Upper Burma...From *Centropus b. bengalensis* (Gmelin): 1 male, 3 females, 22878, May 6, 1945; 3 males, 22848, April 18, 1945; 5 males, 22856, April 30, 1945; 5 males, 1 female, 22879, May 1, 1945; 1 female, 22896, May 2, 1945; 2 males, 22860, January, 1945. From the crow pheasant, *Centropus sinensis intermedius* Hume: 2 males, 3 females, 22890, February 18, 1945; 1 male, 22888, April 18, 1945; 1 male, 1 female, 22871, July 13, 1945; 2 males, 22852, July 14, 1945; 1 male, 22911, July 23, 1945; 1 male, 1 female, 22623, September 21, 1945; 1 male, 1 female, 22746, October 3, 1945. From the junglefowl, *Gallus gallus gallus* (Linn.): 1 male, 22891, May 25, 1945. From the pied harrier, *Circus melanoleucos* (Forster): 1 male, 22876, May 3, 1945. From the bulbul, *Pycnonotus jocosa jocosa* (Linn.): 1 male, 22913, February 18, 1945.

Malaya. From *Centropus bengalensis javanensis* (Dumont): 4 males, 1 female, 25764, Kuala Lumpur, Selangor, April 20, 1948 (R. Traub and C. B. Philip); 6 males, 2 females, 25768, Sungei Way, Selangor, May 31, 1948 (R. Traub and C. B. Philip).

Philippines. From *Centropus bengalensis javanensis* (Dumont): 2 males, 24556, Puerto Princesa, Palawan Island, April 16, 1947 (H. Hoogstraal); 2 males, 1 female, 24557, host and locality as above, April 9, 1947 (H. Hoogstraal).

Types are deposited as follows: Holotype, allotype and paratypes in the Rocky Mountain Laboratory, Hamilton, Montana; paratypes of both sexes have also been deposited in the U. S. National Museum, Washington, D. C.; the Chicago Natural History Museum, Chicago, Illinois; the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; the British Museum (Natural History), London, England; and the National Museum of the Philippines, Manila.

This new species is related to *Haemaphysalis hoodi hoodi* Warburton and Nuttall, 1909, known from several African birds including two species of the genus *Centropus*. Both sexes differ however, in not having palpal article 3 recurved to a definite point at the posterior internal angle as figured by Nuttall and Warburton (1915, figs. 423, 424). In the male of *centropi* the lateral grooves cross two festoons on each side, while in *hoodi* only one festoon is crossed. In the female the porose areas are oval rather than reniform and the cornua, although short, are well developed.

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THE HELMINTH PARASITES OF BIRDS. II. A NEW SPECIES OF ACANTHOCEPHALA FROM NORTH AMERICAN BIRDS[1]

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AND

J. FRED DENTON[3]

During the summer of 1947 a new species of ACANTHOCEPHALA was encountered in a single specimen each of the Canada warbler, *Wilsonia canadensis* (L.), from Mountain Lake, Virginia, and Parula warbler, *Compsothlypis americana* (L.), from Augusta, Georgia. The new species, for which the name *Apororhynchus amphistomi* is proposed, represents the third species to be described for the genus *Apororhynchus* Shipley, 1899, family APRORHYNCHIDAE, Shipley, 1899, and is the first record of the occurrence of an acanthocephalan of this type in North American hosts.

Shipley (1896) created a new genus; *Arhynchus,* for the reception of a new species of ACANTHOCEPHALA, *A. hemignathi,* of which seven specimens, six females and one male, had been recovered from the cloaca of the Honey creeper, *Hemignathus procerus,* in the Sandwich (Hawaiian) Islands. Shipley recognized the uniqueness of his new species among the already described ACANTHOCEPHALA, and since it differed so markedly from all previously known species he created a new family, ARHYNCHIDAE, for the reception of the new genus. Later, however, it was determined that the name *Arhynchus* was preoccupied (beetle) and Shipley (1899) offered *Apororhynchus* as a substitute name for the genus created by him in 1896.

A second species, *Apororhynchus aculeatus,* was described by Meyer (1931) from a single female specimen which he found deposited in the Berlin Museum. The specimen had been taken from the digestive tube of *Oriolus cristatus* from Santos, Brazil. Meyer first studied the specimen from a whole mount and then from sections, the anterior half being cut transversely and the posterior half longitudinally. Meyer found his species to differ from the one described by Shipley in the presence of numerous fine spines on the bulb-shaped proboscis and in the host and geographical locality from which each came. In all other respects the two species appeared to be identical as was pointed out by Meyer.

The material in the present collection consists of eighteen specimens, thirteen from the Canada and five from the Parula warbler. Sixteen of the specimens are females and two are males: one of the males and four of the females were sectioned for study while the remaining specimens represent whole mounts. In each host the parasite was found securely anchored to the digestive tube by means of the imbedded proboscis. The individual parasites, particularly in the Canada warbler, were attached in such a way that the aggregate formed a complete ring of wart-like bodies

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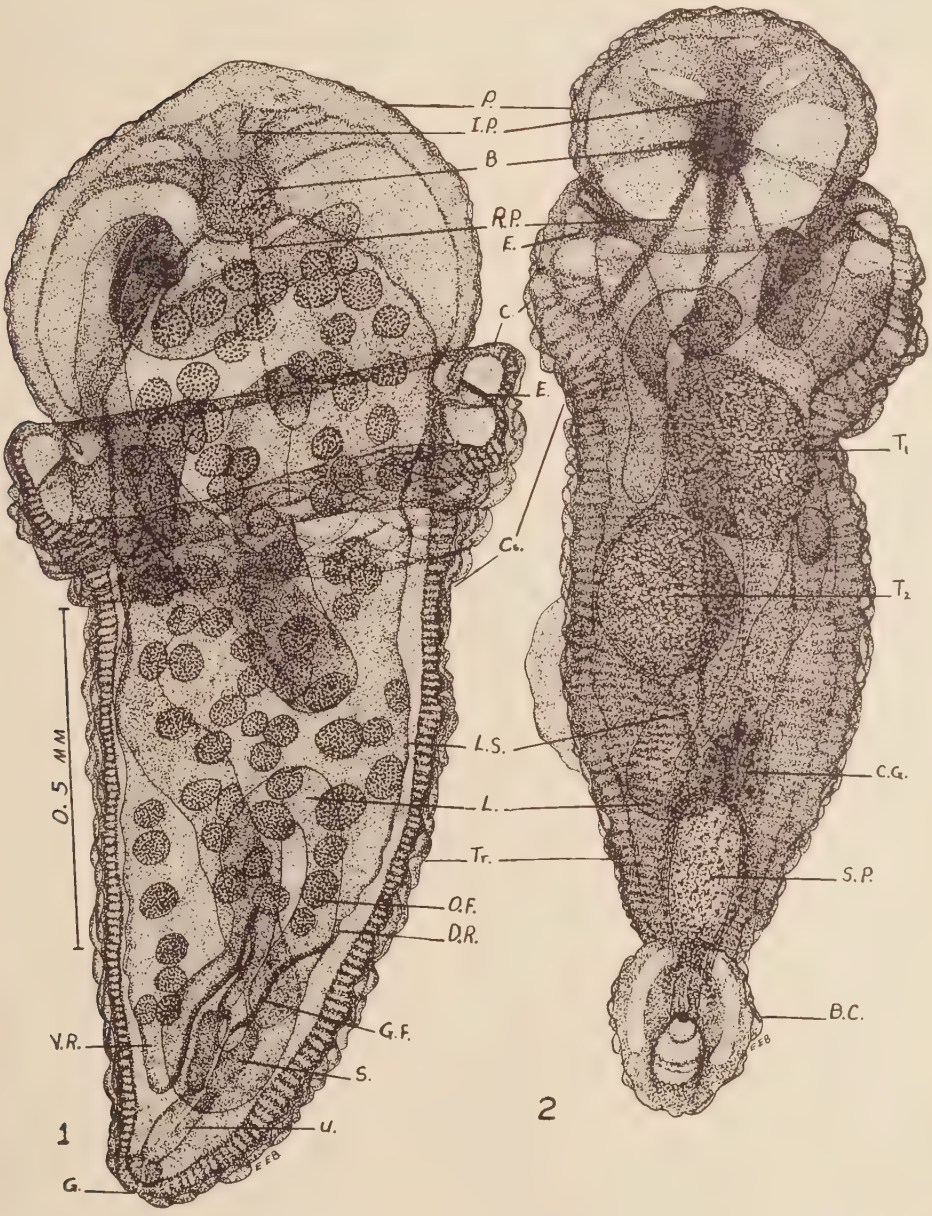
around the digestive tube just inside the vent. While the worms were still in place in the host the semi-transparent proboscides could be seen, all spread out beneath the superficial tissue of the digestive tube, and the numerous very fine hooks on each proboscis clearly indicated one means of attaching the imbedded organ. On exposure and examination of the parasite *in situ* the observer got the definite impression of a number of amphistomate trematodes with their anterior ends swinging free in the lumen of the tube and their powerful posterior suckers firmly gripping the host's tissue. It is because of this superficial resemblance of the parasite to the amphistomate trematodes that the specific name *amphistomi* is suggested for the present species.

Apororhynchus amphistomi new species
(Figures 1–28)

General diagnosis: APORORHYNCHIDAE: Body (Figs. 1 and 2) small in size, sub-conical in shape, slightly curved ventrally, a pinkish, dirty-white in color and differentiated into a proboscis and a trunk. Wall of body varying in thickness, with open sinuses for circulating fluid and covered externally by a relatively thin cuticle (in the preserved worm the cuticle appears to be thrown into a series of folds and wrinkles, giving the exterior the appearance of being rough and warty). Proboscis bulbar in shape in preserved specimens, widest anterior to its middle, tapering more gradually back to its union with wall of trunk. Anterior portion of proboscis wall infolded into cavity of proboscis. Cuticle covering proboscis dips into numerous deep, pit-like depressions (Figs. 5 and 21, *P.P.*) in underlying tissue, with each depression containing a very fine hook. Hooks (Fig. 4) numerous, very fine, shaped like a big-headed tack, with a heavy, conical base, a short, slender shank and a curved tip, arising near inner margin of wall and extending outward far enough for a portion of shank and tip to be exposed in bottom of depression but failing to reach outer margin of proboscis wall, irregularly arranged in spiral rows (Fig. 3, *Sp.*), with approximately 20 hooks in each row and about 40 rows. Trunk sub-conical in shape, with stronger curvature dorsally than ventrally, separated by slight constriction (Figs. 1 and 2, *Cs.*) into a dilated anterior part (hereafter called "collar") and a more conical posterior part, expanding slightly posterior to constriction before tapering gradually to a broadly rounded caudal extremity. Anterior to constriction trunk wall becomes considerably thickened and arches outward and upward, gradually diminishing in thickness in passing forward until at a level in advance of its union with proboscis it becomes quite thin, from whence it turns sharply inward and backward (forming inner wall of collar) to its union with wall of proboscis (thus, collar is formed by a thickening (*C.*), thinning and infolding (*I.C.*) of the trunk wall just caudal to the area of the junction of proboscis (*P.*) and trunk, Fig. 25). Neck absent or greatly reduced. When basal portion of proboscis is drawn down into collar fold three or four rows of spines are present on inner wall of collar (Figs. 5, 21 and 24, C.*Sp.*) : when proboscis is fully extended inner wall of collar is almost completely eliminated. Body cavity large, continuous throughout entire length of proboscis and trunk. Lacunar system with dorsal and ventral longitudinal canals (Figs. 12 and 22, *D.L.* and *V.L.*) in trunk and numerous open lacunae which anastomose freely with each other and with longitudinal canals. Lacunae of trunk form more or less circular pattern (Fig. 2) in their ramifications of subcuticula. Lacunar system of proboscis without main canals, lacunae generally arranged longitudinally. Lemnisci two in number (Fig. 1, 2, 27 and 28, *L.*), longer than total length of body, greatly folded and looped in body cavity, originating laterally from subcuticula at junction of proboscis and inner wall of collar, containing central canal (Figs. 12, 21 and 22, *La.L.*) which is continuous with lacunae of proboscis wall, and from 9 to 11 giant nuclei each (Figs. 27 and 28, *L.N.*) ; nuclei averaging 109 μ long, 88 μ wide and 50 μ deep. Giant nuclei of subcuticula numbering from 28 to 31 (Figs. 27 and 28, *C.N.*), averaging 96 μ long, 78 μ wide and 45 μ deep, confined to wall of trunk below level of constriction. Genital pore (Figs. 1, 11, 26, 27 and 28, *G.*) at caudal tip of ventrally flexed posterior extremity.

Female: Body (Fig. 1) 2.13 (1.46–2.78) mm long by 0.83 (0.60–1.10) mm in maximum width at collar. Proboscis wider than long, 0.44 (0.21–0.60) mm long by 0.74 (0.55–0.92) mm in maximum width. Collar 0.33 (0.21–0.43) mm long by 0.83 (0.60–1.10) mm in maximum width. Trunk constricting to 0.63 (0.43–0.78) mm in width just behind collar, expanding slightly behind constriction before tapering back to broadly rounded caudal extremity (0.13 (0.11–0.15) mm broad). Brain ganglion (Figs. 1, 3, 5, 20 and 27, *B.*) imbedded in loose



Apororhynchus amphistomi n. sp.
Figures 1–28

FIG. 1. Lateral view of female specimen showing the more obvious details of the anatomy. Note: the ova are omitted from the sketch so as to show the extent of the ligament sac, the general distribution of the ovarian fragments and the unusually long lemnisci.

FIG. 2. Ventral view of male specimen showing the everted bursa copulatrix and the more obvious details of the anatomy. Note that the accessory pouch and cement glands are pulled well down into the caudal limits of the body cavity.

strands of tissue close to inner margin of proboscis wall, approximately 0.08 (0.06–0.09) mm long by 0.09 (0.08–0.10) mm wide and lies 0.18 (0.13–0.24) mm behind uninvaginated portion of anterior proboscis wall. Ligament sac (Figs. 1, 5, 6, 23 and 27, *L.S.*) almost straight, slender tube in young females, expanding with age of worm, occupying practically entire body cavity in fully gravid specimens, extending from region of brain ganglion to near posterior end of body cavity, separating into dorsal and ventral rami (Figs. 1, 8 and 9, *D.R.* and *V.R.*) a short distance in front of genital funnel. Dorsal ramus of ligament sac tapering slightly before differentiating into genital funnel (Figs. 1, 8, 9 and 27, *G.F.*). Ventral ramus passing posteriorly, fusing for short distance with median wall of genital funnel, terminating a short distance in front of extreme caudal limit of body cavity. Genital complex consisting of usual funnel, at base of which lie three rather large muscular selector cells (two dorso-lateral and one ventral in position, Figs. 8, 9 and 27, *S.*), each containing two small nuclei. Uterus (Figs. 1, 8, 10 and 27, *U.*) very short and thick-walled, arising from tissue of funnel and selector apparatus, terminating at rather heavy sphincter muscle (Figs. 8, 10, 11 and 27, *S.M.*) which guards entrance of uterus into genital bulb. Atrial funnel (Figs. 8, 10 and 27, *A.F.*) consisting of two rather large, slightly hollowed-out cells (each containing a nucleus) which occupy terminal portion of uterus, just in front of sphincter. Genital bulb (Figs. 8, 11 and 27, *G.B.*) in contact with inner margin of body wall at caudal tip of body cavity. Entire genital complex approximately 0.38 (0.34–0.43) mm in extent by 0.10 (0.09–0.10) mm in maximum width. Genital pore opening to outside at caudal tip of ventrally flexed trunk. Ovary separating into a large number of small fragments. Ovarian fragments (Figs. 1, 5 and 6. *O.F.*) varying in number from a very few in young females to as many as 135 in one gravid specimen and rather evenly scattered throughout entire ligament sac, being sparated one from another by numerous ova in varying stages of development. Mature and developing ova (Figs. 5, 6, 9 and 23, *O.*) almost completely filling ligament sac from region of brain ganglion to posterior end, separated one from another by a gelatinous-like fluid (Fig. 23, *G.E.*). Mature embryos (Fig. 7) with three membranes, the middle one of which is rather heavy, measure 52 (48–64) μ long by 27 (20–30) μ wide: many developing embryos without shell membranes. Developing larva with numerous nuclei and six (?) blade-like spines.

Male: Body (single mounted specimen, Fig. 2) 1.43 mm long by 0.58 mm in maximum width at collar. Proboscis wider than long, 0.36 mm long by 0.44 mm in maximum width. Collar narrow, 0.21 mm long by 0.58 mm in greatest width. Trunk constricting to 0.39 mm wide just behind collar, quickly expanding to 0.46 mm in width before tapering gradually to broadly rounded caudal extremity (0.15 mm wide at extroverted bursa). Brain ganglion (Fig. 2, *B.*) imbedded in loose strands of tissue which arise from anterior wall of proboscis, 94 μ long by 77 μ wide, located 128 μ behind inner margin of uninvaginated portion of anterior wall of proboscis. Ligament sac (Figs. 2, 21 and 28, *L.S.*) originating from tissue about brain ganglion, passing back through cavity of proboscis and collar region as slender bundle of fibers, rather suddenly expanding posterior to level of collar to inclose male organs, ultimately fusing with bursa and vesicular tissue of bursal cap. Testes (Figs. 1, 12, 13, 22 and 28, *T.*) rather large, slightly ovoid in shape, measuring 0.26 mm long by 0.21 mm wide for anterior and 0.25 mm long by 0.22 mm wide for posterior testis, with anterior testis lying mostly to right of midline and posterior testis lying mostly to left of that line although median and transverse planes may overlap slightly: anterior testis at or just caudal to level of constriction and posterior testis as much as 0.48 mm in advance of caudal end of body. Vasa efferentia (Figs. 12 and 28, *Ve.*) arising from mid-dorsal aspects of testes, following wall of ligament sac for short distance before converging mesially to become fused into vas deferens (Figs. 12 and 28, *Vd.*) in region of cement glands. Vas deferens descending amid cement glands and their ducts as a slender, slightly dilated tube, the seminal vesicle (Figs. 13, 14 and 28, *S.V.*), finally reducing its diameter and developing a stronger wall, the ejaculatory duct (Figs. 15, 16, 17, 18 and 28, *Ej.*), before entering genital papilla (Figs. 16, 17, 18, 19, 26 and 28, *G.P.*), opening into cavity of bursa from caudal tip of papilla. Ejaculatory duct giving rise to two short, slightly dilated blind pouches (Figs. 15 and 16, *Ej.P.*) ventrally just before entering genital papilla. Cement glands (Figs. 2, 12, 13 and 28, *C.G.*) eight in number, rather large and pear-shaped, each containing a nucleus and large secretion cavity, gradually tapering posteriorly to form a rather slender duct (Figs. 14 and 28, *D.C.*) which passes posteriorly along side of seminal vesicle and accessory pouch to near genital papilla where the four ducts from each side unite into a single fusion duct. Fusion duct from each side enters ejaculatory duct laterally just as it enters genital papilla. Mass of cement glands (exclusive of ducts) approximately 0.25 mm long by 0.13 mm wide. Accessory (Saefftigen's) pouch large (Figs. 2 and 28, *S.P.*), 0.36 mm long by 0.14 mm in maximum width (near its anterior limits) when bursa is extroverted and approximately 0.43 mm long by 0.24 mm in maximum width when bursa is withdrawn into

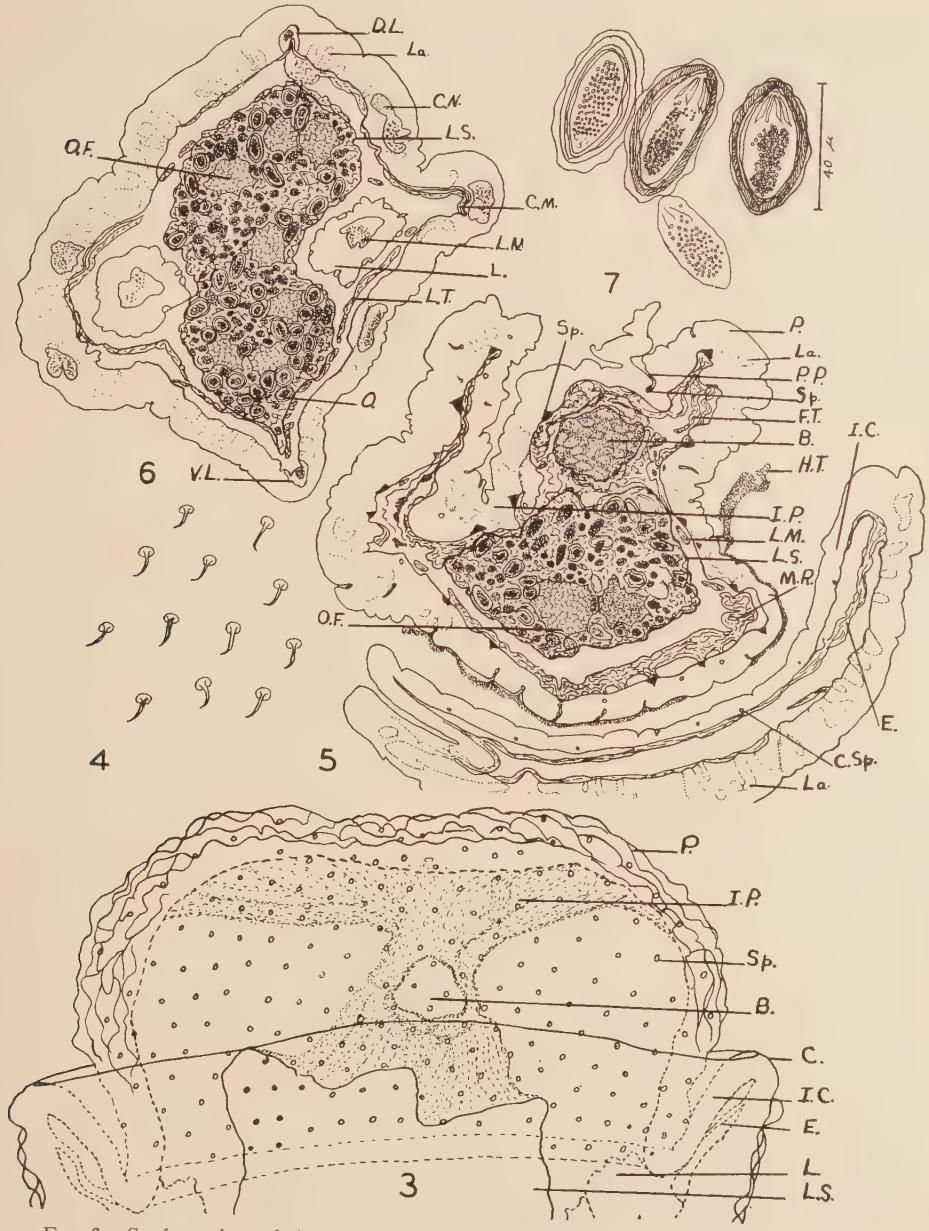


FIG. 3. Surface view of the anterior end of a female specimen showing the connection of the proboscis and collar wall when the base of the proboscis is drawn down into the collar fold. Note the relative position of the brain ganglion and the arrangement of the hooks on the proboscis.

FIG. 4. Diagrammatic representation of the type and arrangement of the hooks on the proboscis. Note: the arrangement of the hooks is not constant over the entire surface of the proboscis.

FIG. 5. Slightly diagonal section through the upper end of the collar and proboscis showing the infolded portion of the proboscis wall, a portion of the ligament sac in the cavity of the proboscis, the brain ganglion, the circular muscle ring and the nature of the tissue about the brain ganglion. Note: some of the host's tissue is still held in place by the proboscis hooks.

FIG. 6. Cross section through the trunk of a female specimen showing the ligament sac with several ovarian fragments and numerous ova in varying stages of development, the two lemnisci, the dorsal and ventral longitudinal canals of the lacunar system and five giant nuclei in the subcuticula.

FIG. 7. Four ova, three with and one without shell membranes.

body cavity, surrounded by heavy muscular wall anteriorly (Figs. 13 and 14), gradually tapering posteriorly from its maximum width, ultimately becoming a narrow tube (Figs. 15 and 16) which dilates slightly before merging (Figs. 17, *E.S.*) with tissues of bursal cap. Bursal cap (Figs. 16, 17, 18, 19, 26 and 28, *G.C.*) consisting of a reversed cup-shaped band of vesicular tissue, surrounding inner end of introverted bursa, with genital papilla and ejaculatory duct entering bottom of reversed cup and bursal tissue invading open end of cup when the latter organ is withdrawn into body cavity, serving as main supportive tissue of extroverted bursa copulatrix (Fig. 2). Bursa (Figs. 2, 26 and 28, *B.C.*) composed mostly of rather loose fibrous tissue when introverted (Figs. 26 and 28), becoming a bulbar, cup-like structure when extroverted. Bursa copulatrix consisting of tissues of bursa and bursal cap, with cuticular inner lining of introverted bursa becoming outer surface and tissue of bursal cap forming central core of extroverted bursa copulatrix. Tissue of bursal cap becoming filled with fluid from accessory pouch to give extroverted bursa copulatrix its characteristic shape and size. Extroverted bursa copulatrix approximately 0.24 mm long by 0.22 mm wide.

Hosts: Wilsonia canadensis (L.) and *Compsothlypis americana* (L.)

Habitat: Digestive tract, just inside the vent.

Localities: Mountain Lake, Virginia, and Augusta, Georgia, U.S.A.

GENERAL CONSIDERATIONS

In studying the material in the present collection it soon became obvious that the authors were not dealing with a conventional species of ACANTHOCEPHALA. This conclusion is attested by the fact that throughout all preliminary observations the organism was considered to be an unusual type of amphistomate fluke, possessing spines on its posterior adhesive organ. Further, the writers recall the statement made by Shipley (1896) concerning the species described by him ". . . . they have an almost ludicrous resemblance to a young *Balanogossus* with one or two gill-slits." Such resemblances of these forms to other organisms are purely superficial in nature and are emphasized here for the purpose of calling attention to the possibility that these or closely related forms might have been mistaken at first glance for other organisms, and now are relegated to some general collection without their having been given further study.

Although Shipley (1896) rather adequately described the general external morphology and lacunar system of *Apororhynchus* (= *Arhynchus*) *hemignathi,* several features of the anatomy of the species could not be made out accurately in the material studied by him. Shipley failed to observe the spine-like hooks on the proboscis and, in fact, questioned the presence of a proboscis in his material, although judging from the position of the bulb-shaped anterior part of the worm, its association with the ligament sac and the continuity of its wall with the lemnisci he logically concluded that this organ was a proboscis. In describing this organ Shipley made no mention of the infolded anterior wall although his figures II and III, pl. 12, clearly indicate the presence of the feature. On the other hand, Meyer (1931) called attention to the presence of numerous fine hooks on the bulbiform proboscis and described and illustrated the infolding of the proboscis wall in *A. aculeatus* (Fig. 4, p. 66). Since certain features of the anatomy in the material available to Shipley could not be worked out in detail, and since only a single female specimen was studied by Meyer, several previously inadequately considered or undescribed anatomical parts remain to be described for a member of the genus. In the hope of throwing some light on the general anatomy of an acanthocephalan species in which the proboscis is not a true introvert and in which the proboscis receptacle is wanting, certain of these undescribed features, together with the authors' interpretations of their functional relationships, will be considered in the present paper.

In the present material the proboscis clearly shows an infolding of the anterior wall (Fig. 5, *I.P.*) in sectioned specimens. The nature of this infolding is less readily discerned in specimens mounted *in toto* (Figs. 1, 2, 3, 20, 27 and 28). In the whole mount the infolded wall of the proboscis appears as rather heavy bands (folds) of tissue which originate from the inner margin of the proboscis wall and converge mesially, forming a wedge- or funnel-shaped structure extending back into the cavity of the proboscis as far as the level of the brain ganglion. In both the sectioned and *in toto* mounted specimens the wall of the proboscis is quite thin, 20 to 30 μ thick, at its union with the inner wall of the collar. Anteriorly it gradually increases in thickness until it attains a thickness of 80 to 110 μ around the edges of the infolded portion. The thickness of the infolded part (Fig. 5, *I.P.*) is difficult to determine accurately due to its greatly wrinkled or folded condition. Where measurements on this part were possible it was found to be from 20 to 30 μ less than the maximum thickness of the "lateral" wall. The greater thicknesses of the wall appear to be due in part to the less fibrous nature of the subcuticula and in part to the more open sinuses of the lacunar system. In those specimens which were removed from the host along with sufficient host tissue for the proboscis to remain in the imbedded condition it was seen that the proboscis had been thrust through a relatively small penetration opening and that the collar was tightly pressed against the outer surface of the tissue. Beyond the insertion opening, the wall of the proboscis spread out in all directions so that it lay firmly anchored by the very fine hooks (with host tissue pulled down into the pit-like depressions of the proboscis wall, Fig. 5, *H.T.*) to the proximal wall of a large vesicular cavity in the gut wall. This anchored part of the proboscis was quite thin while all of the forward part of the wall was much thicker and spongy, and was collapsed to a point that the proboscis presented the picture of a flat, button-like organ which had been rammed through a small penetration opening. The collapsed forward wall of the proboscis took stain more readily than did the remainder of the body wall and several masses of a deeply staining, granular material appeared in the proboscis cavity just under the collapsed wall. If the wall of the complete proboscis had been in direct contact with the tissues of the host, the forward part had become disassociated in the two specimens so examined, and the collapsed wall had left approximately two-thirds of the vesicular cavity in the host's tissue completely free of the parasite. Due to the nature of the tissue of the forward part of the proboscis wall, its staining reaction and the presence of large clumps of granular material beneath the collapsed wall it is suggested that the proboscis in this organism is more than an organ of attachment: it is one of the chief organs of nutrition, carrying on the functions of digestion and absorption. It is suggested further that the species is primarily a tissue parasite, living largely on nutritive substances obtained from the breakdown of host tissue. This suggestion is substantiated in part by the habitat of the parasite, living as it does attached to the wall of the gut just inside the vent.

Shipley (1896) rather adequately described the lacunar system for *Apororhynchus hemignathi.* As in Shipley's species the lacunar system in the present form exhibits a pair of longitudinal canals in the trunk. One of these is mid-dorsal and the other one is mid-ventral in position (Figs. 12 and 22, *D.L.* and *V.L.*) and not laterally located as indicated for *A. hemignathi.* The dorsal and ventral positions of these canals were correctly determined by Meyer (1931) for *A. aculeatus.* In the

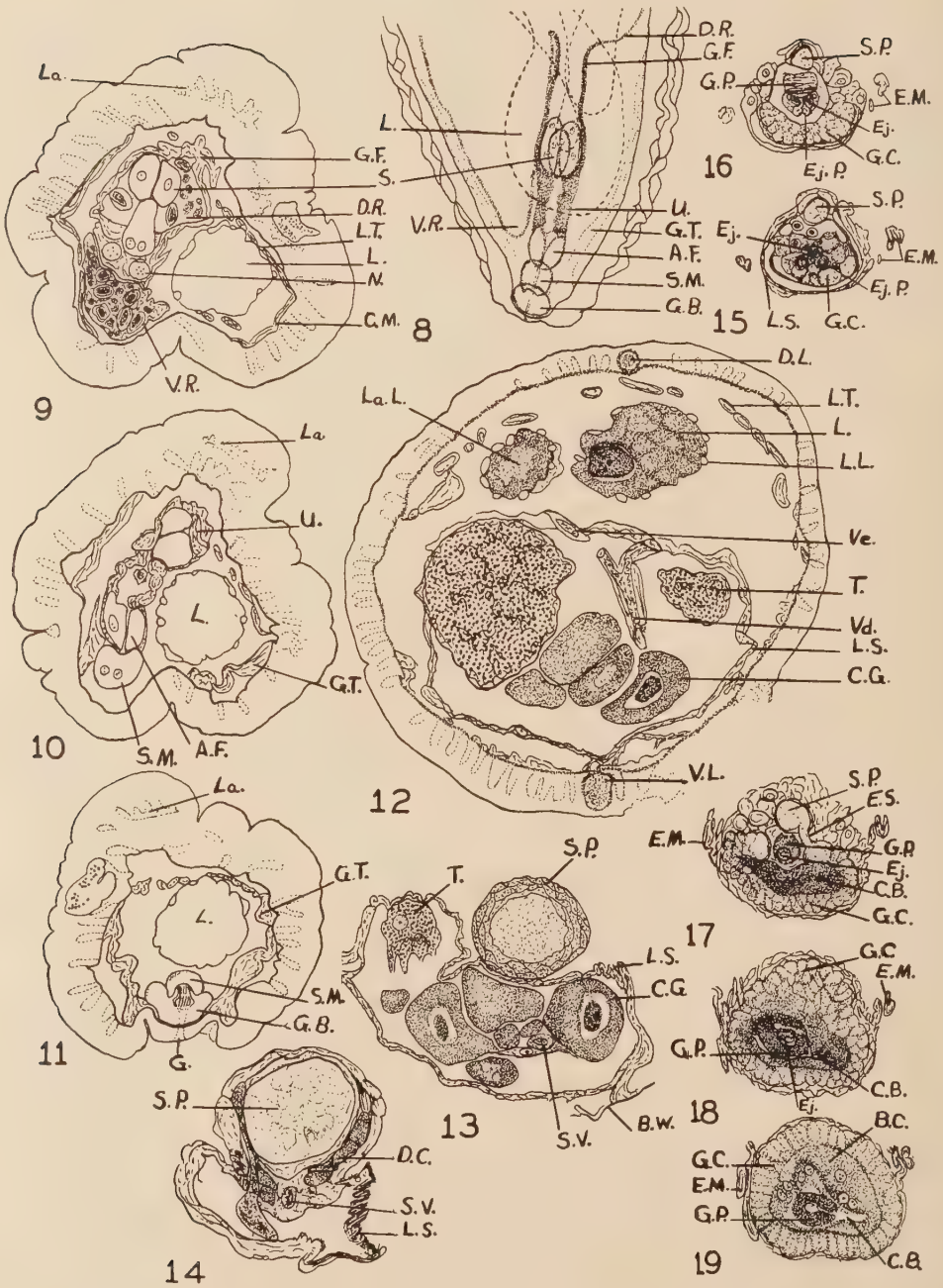


FIG. 8. Diagrammatic reconstruction of the posterior end of the female showing the approximate organization of the terminal features of the genital system.

FIGS. 9, 10 and 11. Three selected sections through the terminal portions of the female genital system showing the selector apparatus, the ventral ramus of the ligament sac, the uterus, atrial funnel, genital sphincter and genital bulb.

FIG. 12. Cross section through the trunk of the male showing the testes, vasa efferentia, vas deferens, four cement glands, ligament sac, lemnisci, longitudinal muscles of trunk and the longitudinal canals of the lacunar system at this level.

present species the longitudinal canals give rise to numerous lateral lacunae (Figs. 5, 6, 9, 10, 11, 12, 21 and 24, *La.*) which in turn freely anastomose with adjacent lacunae. In general the lateral lacunae have a circular arrangement (Fig. 2). In the anterior part of the collar portion of the trunk the lacunar system forms a rather definite circular ring-canal. This sends forward a few small lacunae which communicate with that part of the body cavity isolated by the extensor muscle of the proboscis. The inner wall of the collar is practically devoid of lacunae, and there appears to be no connection between the lacunar system of the trunk and that of the proboscis. On the other hand, there is an open connection between the lacunar system of the proboscis wall and the central canal of each lemniscus. The lemnisci arise laterally from the subcuticula at the point of union of proboscis and inner wall of the collar, the subcuticula at these points apparently invaginating into the body cavity to form the two greatly elongated, finger-like bodies of the lemnisci. The central canal (Figs. 12 and 21, *La.L.*) in each lemniscus gives rise to many short lateral canals throughout its course and then opens directly into the lacunar system of the proboscis wall. In the proboscis the lacunae tend to run in a longitudinal direction although there are numerous lateral, anastomosing lacunae and many relatively large open spaces in the ramifying lacunar system. The wall of the anterior half of the proboscis is particularly well supplied with the large open spaces, which in part may account for the increased thickness of this part of the wall. Undoubtedly the fluid within this system of lacunae is shifted alternately between the proboscis and the lemnisci in coordination with the contraction and relaxation of the body muscles.

Movements involving the anatomical parts are accomplished through the coordinated action of special muscles. The basal portion of the proboscis can be drawn down into the fold of the collar or it may be extended far enough as to almost completely eliminate the inner wall of the collar fold. This extension and withdrawal of the basal portion of the proboscis is accomplished in part by the action of three separate muscle groups. The first of these is a circular band of muscles, the sphincter (Figs. 20, 21 and 25, *C.R.*), which is firmly anchored to the inner margin of the basal portion of the proboscis wall just anterior to the union of the proboscis and inner wall of the collar. The sphincter serves as the point of origin for two latero-radial muscles (Figs. 20, 21 and 25, *L.R.*) which pass inward and upward to become inserted in the tissue about the brain ganglion. When the proboscis is to be thrust forward the sphincter relaxes as do the latero-radials, thus permitting the base of the proboscis to become expanded and the tissues surrounding the brain ganglion to be elevated. When the proboscis is to be drawn downward into the fold of the collar

FIG. 13. Cross section through the ligament sac of the male showing the arrangement of the male organs and ducts near the cephalic end of the accessory pouch. Note the heavy muscle surrounding the accessory pouch and an attachment of the ligament sac to the body wall.

FIG. 14. Cross section through the ligament sac of the male near the posterior limits of the cement glands. Note the continuity of the muscles of the ligament sac and those surrounding accessory pouch.

FIGS. 15 and 16. Two sections (one section apart) through the ligament sac at inner margin of the bursal cap. Note the accessory pouch, the two blind pouches of the ejaculatory duct and the genital papilla.

FIG. 17. Cross section through bursal cap at level of fusion of accessory pouch and tissues of the bursal cap.

FIGS. 18 and 19. Cross sections (one section apart) through the bursal cap showing the tissue of the bursal cap, the opening of the ejaculatory duct and the invasion of the bursal cap by bursal tissues.

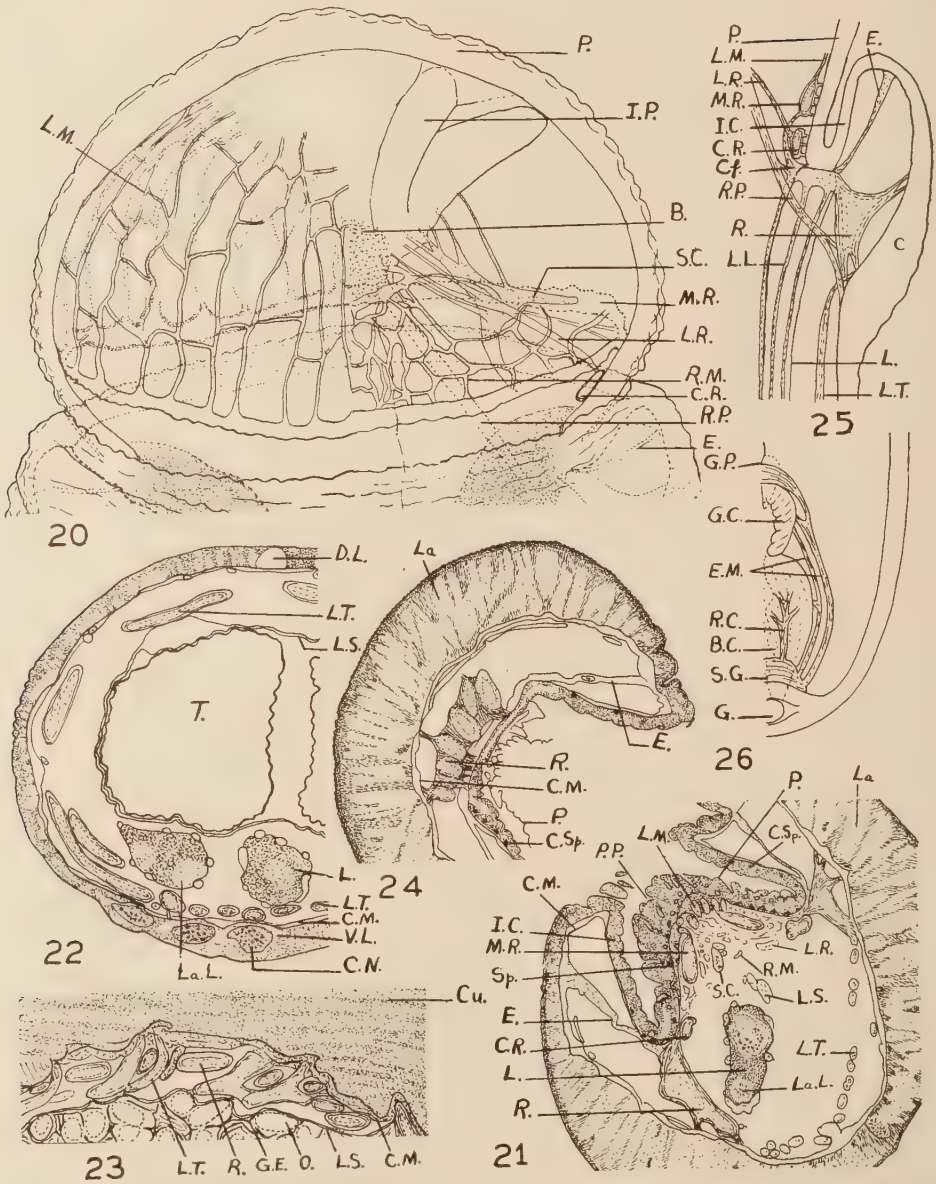


FIG. 20. Optical section of the proboscis showing the circular muscle ring with its longitudinal muscle fibers on the left and the reticular-like muscles, a stellar-like muscle and a lateroradial muscle on the right side. Note the infolded anterior wall of the proboscis.

FIG. 21. Slightly diagonal section through the edge of the proboscis and upper end of the collar showing the arrangement of the muscles associated with the proboscis and some of the longitudinal muscles of the trunk. Note the deep, pit-like depressions in the cuticle of the proboscis and the associated hooks underneath.

FIG. 22. Cross section through the trunk of the male at the level of the testes showing the arrangement of the longitudinal muscles of the trunk, the lemnisci and the longitudinal canals of the lacunar system.

FIG. 23. Portion of a cross section through the body wall at the point of origin of the retractor and longitudinal muscles. Magnification twice that of the other sections.

the sphincter contracts, constricting the basal part for convenience in adjusting it into the collar fold. When the sphincter contracts the latero-radials associated with it contract also, thus assisting in the depression of the brain ganglion and forward portion of the proboscis wall.

The second muscle associated with the forward-backward movement of the proboscis is concerned only with the forward motion of the organ. This is a thin, washer-like sheet of muscles, the extensor (Figs. 1, 2, 3, 5, 20, 21, 24, 25 and 28, *E.*), which completely surrounds the basal portion of the proboscis. The muscle takes its origin from the inner margin of the proboscis wall at the point where this unites with the inner wall of the collar and stretches upward, when the proboscis is drawn down into the collar fold, to insert in the inner margin of the collar wall a short distance posterior to the level where the collar becomes folded inward. The muscle, then, cuts off a small portion of the body cavity which, together with the muscle itself and the unoccupied portion of the body cavity immediately behind it, undoubtedly produces the impression of the "one or two gill-slits" (Fig. 1) mentioned by Shipley when he compared his species to "a young *Balanogossus.*" When the extensor contracts it tends to pull the outer wall of the collar in under the base of the proboscis (Fig. 5) and thus forces the proboscis forward. When the muscle relaxes the wall of the collar returns to its expanded condition and the base of the proboscis is free to be drawn back into the fold of the collar.

The third muscle involved in the movement of the proboscis is purely a retractor muscle. It is a relatively thin, sheet-like muscle which completely surrounds the basal portion of the proboscis (Figs. 21, 24 and 25, *R.*). The retractor originates as numerous, very slender muscle cells from the trunk wall at about the level where it increases its thickness to form the caudal limits of the collar, *i.e.*, just in front of the constriction. These several cells (Fig. 23, *R.*) soon become fused into a solid sheet of muscle (Fig. 24) which continues forward to insert in the subcuticula where proboscis and inner wall of collar meet. Strands of muscle from the anterio-lateral aspects of the retractor spread out onto the lemnisci (Fig. 25) and form the longitudinal muscles of these two bodies (Figs. 12 and 25, *L.L.*). Two other muscles, one on either side (Fig. 25, *Cf.*), originate from the anterio-lateral aspects of the retractor. These pass upward to insert in the circular muscle ring of the proboscis. Some fibers from the retractor muscle pass outward from about the middle of its length and insert in the collar wall midway between the point of origin of the retractor and the insertion of the extensor. When the retractor muscle is relaxed the proboscis can be extended: when it contracts the proboscis is drawn downward into the fold of the collar. Thus, by the contraction of the spincter muscle the base of the proboscis is reduced in diameter whereas the action of the extensor muscle forces the proboscis forward (and expands the base of the proboscis) while the retractor muscle draws the base of the proboscis back into the collar fold. In all

FIG. 24. Slightly diagonal section through a portion of the collar showing the fusion of the originating fibers into the retractor muscle of the proboscis. Note the outline of the extensor muscle.

FIG. 25. Diagrammatic optical section through a portion of the body wall showing the union of the proboscis wall with the inner wall of the collar. Note the origin of the lemniscus and the positions and relationships of the associated muscles.

FIG. 26. Diagrammatic reconstruction of the terminal portion of the male genital system showing the muscles associated with the inverted bursa and bursal cap.

probability the work accomplished by these three muscle groups is aided by other muscles which have a direct bearing on the proboscis or by causing other organs and the body fluids to be shifted within the body so as to exert pressure in appropriate locations.

In addition to the muscles just described there is a complete ring of muscles (Figs. 5, 20, 21 and 25, *M.R.*) attached to the inner margin of the proboscis wall a very short distance in front of the sphincter muscle. In general it is a broad, relatively thin muscle band and is securely anchored to the proboscis wall by numerous very short fibers (Fig. 5). The muscle ring receives in the lateral positions the two (one on either side) short muscles from the anterio-lateral aspects of the retractor muscle, and gives rise to many longitudinal muscles (Figs. 20 and 21, *L.M.*) from its anterior margin. These longitudinal muscles pass upward in close apposition to the inner margin of the proboscis wall to become lost in the adventitia just under the anterior wall of the proboscis. In passing forward they branch, forming a partial network of fibres (Fig. 20). Although the exact pattern of this network in the extreme anterior part of the proboscis could not be made out, certain features of the pattern would indicate that the muscles ultimately formed a mesh of fibers underneath the extreme anterior wall. In all probability these muscles together with the muscle ring function in such a way as to reduce the overall size of the proboscis and, thus, aid in the expulsion of fluid from the lacunar system of the proboscis wall.

In describing the tissue underneath the anterior wall of the proboscis in *Apororhynchus hemignathi,* Shipley (1896) stated: "Owing to the absence of an introvert and its sheath, the relations of the ligament in the species is somewhat altered. It takes its origin from the anterior end of the head, and at first seems to consist of a few strands of muscle fibers which arise from the muscles of the skin." On the other hand, in describing the anatomy of *A. aculeatus,* Meyer (1931) stated that ". . . . . the structure in which the proboscis ganglion is imbedded and which corresponds in the others to the proboscis receptaculum (snout-sac) does not represent a real sac with radial-fibrillar walls into which the proboscis may be drawn but is a funnel-shaped, muscleless structure which inserts in the upper part of the proboscis and reaches no further back than the middle of the proboscis, that is, not quite as far as the neck where the lemnisci arise." Further along in his description of the species Meyer stated: "Proboscis receptaculum very thin-walled—without radial fibers in its wall—funnel-shaped and inserted dorsally in the proboscis and reaching back to its middle." In the present species a condition similar to that described by Shipley exists. In no instance could anything even remotely resembling a proboscis receptacle be detected. Even the tissue which, in specimens mounted in their entirety, resembled muscles arising from the anterior wall of the proboscis and which extended posteriorly as a funnel-shaped wedge of tissue to the region of the brain ganglion, failed entirely to conjure up the picture of a proboscis receptacle. On the other hand, in all sectioned specimens a few strands of muscle tissue originated from the inner margin of the proboscis wall (Fig. 5, *F.T.*) and fused into a loose mesh of fibrous tissue about the brain ganglion. The longer and more pronounced of these muscles originated from the inner margin of that part of the proboscis wall immediately surrounding the infolded portion. The brain ganglion (Fig. 5, *B.*), therefore, is imbedded in this loose mesh of tissue formed by the fusion of these individual strands of muscle fibers.

Certain special muscles are associated with the mesh-like tissue about the brain ganglion. Two such muscles, the latero-radials, have been mentioned already: they emerge from the anterio-lateral aspects of the sphincter muscle and fuse with the tissue about the brain ganglion. Many other smaller muscles originate from the medial aspects of the circular muscle ring. These converge anterio-radially to fuse with the mesh of tissue about the brain ganglion. The individual muscles of this group remain fibrillar throughout their course and are connected with adjacent muscles by cross fibers, producing thereby a velum-like reticulum between the tissues surrounding the brain ganglion and the circular muscle ring (Fig. 20, *R.M.*). Two rather large, stellar-shaped individual muscle cells (Figs. 20 and 21, *S.C.*) connect the muscular ring with the tissue about the brain ganglion. One of these cells lies in the right lateral and the other one in the left lateral aspect of the proboscis cavity just below the level of the brain ganglion. Each cell lies more or less parallel to the latero-radial muscle on that side, and gives rise to several very slender fibers anteriorly. These pass upward and inward to fuse with the tissues about the brain ganglion. Posteriorly each cell gives rise to two rather stout fibers which pass downward and outward to fuse with the muscular ring, one in the dorso-lateral and the other one in the ventro-lateral position. One median group of muscle fibers emerges from the posterior aspect of the mesh-like tissue about the brain ganglion. This group passes backward through the body cavity to give rise to the ligament sac (Figs. 1, 2, 21, 27 and 28, *L.S.*). In the gravid female this group of fibers opens up immediately into the membranous ligament sac while in the male and young female the group of fibers extends downward through the body cavity for a considerable distance before expanding into the true ligament sac.

One other pair of muscles is identified in the region of the proboscis. These two muscles (one on either side in the lateral positions, Figs. 1, 2, 20, 25, 27 and 28, *R. P.*) take their origin from the lateral aspects of the trunk wall, at the same level as the origin of the retractor muscle (Fig. 25), and from the proximal fibers of the retractor muscle. Each muscle passes forward, medianly to the retractor, to become imbedded in the mesh-like tissue about the brain ganglion. In passing forward each muscle sends out fibers to the band of muscle which develops the longitudinal fibers of the lemniscus on that side (Fig. 25). The two muscles can be traced anteriorly through the tissue about the brain ganglion to where they fuse with the muscles originating directly from the inner margin of the anterior wall of the proboscis. These two muscles are the retractors of the anterior wall of the proboscis and correspond to the proboscis inverters of other acanthocephalan species. In the vicinity of the brain ganglion lateral nerves are seen in association with the two muscles although these could be traced down the muscles for only a very short distance.

Muscular movement in the trunk is accomplished through the action of two groups of muscles. The first of these is a layer of circular muscles (Figs. 6, 12, 21, 22, 23 and 24, *C.M.*) which for the most part closely adheres to the inner margin of the subcuticula. The circular muscles fail to form a continuous layer of fibers throughout the entire length of the trunk but form rather wide sheets of muscles interspersed with much narrower sheets to give this layer the general appearance of forming a reticular inner lining for the subcuticula. A similar pattern of circular muscles is observed for the proboscis. The second group of muscles

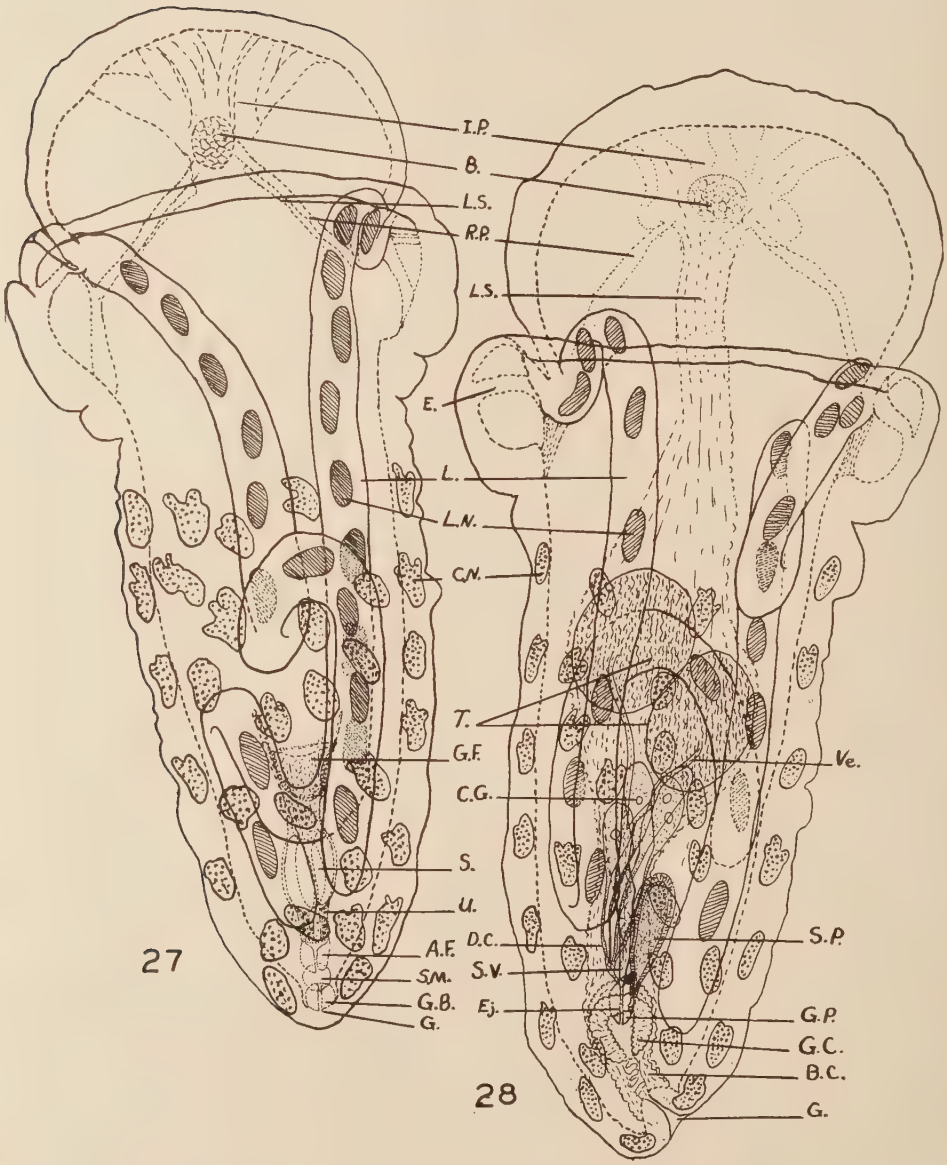


FIG. 27. Outline sketch of female specimen showing the extent of the ligament sac and the location of the giant nuclei of the lemnisci and subcuticula. Note: the nuclei are drawn as if they were all in the same plane.

FIG. 28. Outline sketch of male specimen showing the general internal organization and the extent of the lemnisci. Note: the male genital system is diagrammatically represented and only four of the cement glands are shown. The giant nuclei of the lemnisci and subcuticula are indicated as in figure 27.

consists of longitudinal muscles (Figs. 6, 9, 12, 21, 22, 23 and 25, *L.T.*). These muscles are just internal to the circular muscles and consist for the most part of eight muscles, four ventral, two lateral and two dorsal, with one member of each pair occupying corresponding positions in each lateral half of the body cavity (Fig. 22). They take their origin from the wall of the trunk at the same level as the retractor muscle of the proboscis (just in front of the constriction, Fig. 23, *L.T.*), with each muscle originating as several individual muscle cells. Shortly after originating, from four to twelve individual muscle cells become fused into a single longitudinal muscle. The individual muscles pass posteriorly through the body cavity as they alternately separate into several strands and fuse into a single muscle (in the various sections of the trunk the number of fused or separated muscle strands of the individual longitudinal muscles varies anywhere from 4 ventral, 1 right lateral, 1 left lateral and 2 dorsal to 21 ventral, 5 right lateral, 5 left lateral and 20 dorsal). In the anterior half of their extent one pair of the ventrally located longitudinal muscle lies more median in position than does the other pair (Fig. 22). Ultimately the longitudinal muscles become inserted in the subcuticula near the posterior extremity of the trunk. Throughout their course an occasional fiber becomes inserted in the subcuticulla and an occasional fiber will become inserted in the ligament sac or a lemniscus. The fact that the originating cells of the retractor muscle of the proboscis and the longitudinal muscles of the trunk spring from almost identical locations on the trunk wall, with the originating cells of the two muscles crossing (Fig. 23), may have a significant bearing on the movements of the proboscis and trunk in that the close association of these two groups of muscles may coordinate the shifting of internal organs and body fluids to correspond with contraction and relaxation of the other body muscles.

Certain special muscles are associated with the terminal portions of the reproductive systems. In the female one group of these consists of muscle strands which arise from the genital sphincter and pass up along the outer surface of the genital tract. They function to expand the genital bulb and (?) may aid this organ in becoming extroverted during copulation. A second pair of muscles originates as several strands of muscles from the lateral walls at a level somewhat anterior to the caudal extremity of the trunk. These several strands on each side fuse to produce a pair of strong lateral muscles (Figs. 10 and 11, *G.T.*). They insert in the genital sphincter. These muscles assist in the introversion of the genital bulb and and in producing a marked indentation of the body wall about the genital pore. In the male three pairs of muscles are observed, two pairs of extrovertor muscles and one pair of introvertors. The extrovertor muscles (Figs. 15, 16, 17, 18, 19 and 26, *E.M.*) originate from the genital sphincter and pass anteriorly along the lateral surfaces of the introverted bursa. The more median pair of these sends out fibers which insert in the wall of the bursa and then continues on forward to become inserted in the tissue about the bursal cap. The more lateral pair of muscles passes anteriorly to the bursal cap where each divides into two insertion fibers, the posterior ones of which insert in the tissue about the bursal cap while the anterior ones insert in the tissue of the ligament sac. These muscles assist in the extroversion of the bursa copulatrix. The third pair of muscles (Fig. 26, *R.C.*) originates from ventro-lateral positions on the trunk wall and passes down to insert in the genital sphincter. They function as an aid in the introversion

of the bursa copulatrix. Fibers arising from the longitudinal muscles of the trunk and inserting in the various organs within the body cavity assist in the extroversion-introversion processes in the male.

Certain structures associated with the terminal portions of the male genital system deserve consideration. The elongated, club-shaped organ, variously referred to as Saefftigen's pouch, muscular sac, blind pouch, ejaculatory pouch, etc., characteristic of certain groups of the ACANTHOCEPHALA, is a prominent feature in the reproductive system of the male in the present species (Figs. 2, 13, 14, 15, 16, 17 and 28, *S.P.*). In the sectioned male specimen, in which the bursa is introverted, this organ measures 0.43 mm long by 0.24 mm in maximum width. In passing posteriorly the width of the organ is gradually reduced until near its posterior limits it is represented by a small tube no more than 0.04 mm in diameter (Fig. 16). Beyond this point the tube becomes slightly dilated (0.05 mm) and then opens directly into the spongy tissue of the bursal cap (Fig. 17, *E.S.*). In this specimen the union of the pouch with the bursal cap occurs as much as 0.22 mm in advance of the genital pore. In the specimen mounted in its entirety the bursa copulatrix is completely extroverted (Fig. 2) and the terminal portions of the male ducts and organs are pulled well down into the caudal extremity of the body cavity. In this specimen the pouch measures only 0.36 mm long by 0.14 mm in maximum width, and the posterior termination of the organ lies outside the trunk proper, in the tissue composing the central mass of the extroverted bursa copulatrix. In the sectioned material the wall of the pouch is quite thin throughout its length and appears to be composed of a thin, membranous tissue which is completely devoid of distinguishing characteristics. At the anterior end a rather heavy cap of mucles from the ligament sac completely encompasses the organ (Fig. 13). A little way posteriorly the muscles surrounding the pouch become confluent with similar muscles of the ligament sac, and together they encompass the entire complement of male ducts and organs in the area. The anterior third of the cavity of the accessory pouch is almost completely filled by a network of fibrillae, in which are inbedded two small nuclei. Similar concentrations of fibrillae do not occur in the posterior two-thirds of the cavity of the pouch, and this portion is completely filled with a fluid.

In the introverted condition the tissue of the bursal cap (Figs. 16, 17, 18, 19, 26 and 28, *G.C.*) forms a reversed, cup-like cap of tissue surrounding the terminal portions of the male ducts. The organ is composed of a fibrillar tissue in which numerous vesicular cavities predominate, giving the organ the appearance of a honey-comb-like structure. The accessory pouch fuses with the tissues of the bursal cap, and the fluid filling the cavities of these two organs is continuous. Since the tissue of the ligament sac continues posteriorly to become fused with the tissue of the introverted bursa, the bursal cap is surrounded externally by the ligament, while the tissue of the bursa, with its cuticular inner lining, composes most of the tissue within the confines of the bursal cap. The tissue of the introverted bursa is reversed in position when the bursa copulatrix is extroverted, thus bringing the tissue of the bursal cap to occupy the central position within the extroverted bursa copulatrix. The muscular action necessary for the extroversion of the bursa undoubtedly expresses the contents of the accessory pouch into the vesicular spaces of the bursal cap and causes this organ to become turgid enough for it to give the bursa copulatrix its characteristic shape and size. In the present species, then, the accessory

pouch serves as a reservoir for the fluid of the bursal cap, and can be compared to a lemniscus from a functional point of view.

TAXONOMY

The genus *Apororhynchus* as erected and diagnosed by Shipley (1896, 1899) comprises three species, *A. hemignathi* Shipley, 1896, *A. aculeatus* Meyer, 1931, and *A. amphistomi* n. sp. As pointed out by Meyer (1931), *A. aculeatus* differs from *A. hemignathi* only in the presence of numerous very fine hooks on the proboscis, and hosts from which each came. Since Meyer's species is represented by a single gravid female specimen no information is available for the male and, hence, little or no comparison of this form with the other two species can be made. On the other hand, *Apororhynchus amphistomi* differs from both *A. hemignathi* and *A. aculeatus* in the following respects: (1). The body is smaller, never measuring as much as 3 mm in total length. (2). The proboscis is not as broad as the width of the collar. (3). Giant nuclei of the trunk wall vary in number from 28 to 31 (never as few as 20), and these are arranged as follows: 7 to 8 in the upper left, 6 to 7 in the lower left, 7 to 9 in the lower right and 6 to 8 in the upper right quadrant of the subcuticula posterior to the level of the constriction. (4). Giant nuclei of each lemniscus vary in number from 9 to 11 instead of the three or four indicated by Shipley and Meyer. (5). Different host animals.

Within comparatively recent times various investigators (Luehe, 1911, Southwell and Macfie, 1925, Thapar, 1927, Meyer, 1931, 1933, Witenberg, 1932, Van Cleave, 1936, 1941, and others) have made significant contributions to the taxonomy of the ACANTHOCEPHALA at the higher levels. The details of the schemes of classification proposed by each of these investigators need not be discussed here since the merits of each have been considered in a recent publication by VanCleave (1948). Suffice it to say that the scheme proposed and elaborated upon by Meyer (1931, 1933) offers the most acceptable foundation for the taxonomy of the group that has appeared thus far. Van Cleave (1936) called attention to the inadequacies of Meyer's taxonomic groupings, pointing out the fact that the creation of only two orders (PALACANTHOCEPHALA and ARCHIACANTHOCEPHALA) by Meyer necessitated the employment of too many exceptions for adequate coverage of the group as a whole. Consequently, Van Cleave (1936) erected a third order, EOACANTHOCEPHALA, for the reception of those families and genera which constituted the main exceptions in Meyer's groupings. For this new order Van Cleave proposed two new suborders, GYRACANTHOCEPHALA and NEOACANTHOCEPHALA. Later, Van Cleave (1948) reviewed the entire taxonomic structure of the group and recognized the ACANTHOCEPHALA as a separate phylum of the Animal Kingdom. As constructed by Van Cleave the phylum ACANTHOCEPHALA Rudolphi, 1808, comprises two classes and four orders as follows: Class METACANTHOCEPHALA Van Cleave, 1948, with the orders PALACANTHOCEPHALA Meyer, 1931, and ARCHIACANTHOCEPHALA Meyer, 1931, and the class EOACANTHOCEPHALA Van Cleave, 1936 with the orders GYRACANTHOCEPHALA Van Cleave, 1936, and NEOACANTHOCEPHALA Van Cleave, 1936. The characters by which these classes and orders are distinguished are given in tabular form by Van Cleave (1948, p. 16).

From the present study on *Apororhynchus amphistomi* certain basic morphological characters are made known for a member of the family APORORHYNCHIDAE

which, when viewed in the light of known acanthocephalan characterizations, place this family in bold contrast to all other ACANTHOCEPHALA in the present scheme of classification. The characters of the family group may be summarized briefly as follows: (1), Small forms parasitic about the vent of passerine birds. (2), Body distinctly divided into proboscis and trunk. (3), Proboscis flat or button-shaped in living forms, bulbar and with infolded anterior wall in preserved animals, and incapable of being withdrawn into the body. (4), Proboscis with numerous very fine hooks which are set in deep pits and fail to reach the surface of the proboscis wall. (5), Proboscis receptacle absent. (6), Trunk sub-conical, ventrally flexed, separated by constriction into conical posterior part and anterior dilated part, the collar, which produces a deep fold for the reception of the base of the proboscis. (7), Body cavity continuous throughout proboscis and trunk. (8), Brain ganglion large, imbedded in loose mesh of tissue just under anterior wall of proboscis. (9), Lemnisci as long as or longer than total length of the body, each with (?) nine to eleven giant nuclei. (10), Giant nuclei of body wall large and amoeboid, (?) twenty-eight to thirty-one in number, confined to the subcuticula of the trunk. (11). Main longitudinal canals of the lacunar system dorsal and ventral in position. (12). Cement glands of male eight in number. (13), Ligament sac persistent, extending through entire length of body cavity, in females divided into dorsal and ventral parts near posterior end. (14). Embryos with three membranes. (15). Muscular system complex. Thus, due to the location of the longitudinal canals of the lacunar system and the nature of the cement glands in the male it is seen that the members of the family APORORHYNCHIDAE are placed in the class METACANTHOCEPHALA. Certain features of the family group show closer affinities with the order ARCHIACANTHOCEPHALA than to the order PALACANTHOCEPHALA. However, such features as the presence of (1) unusually long lemnisci with many giant nuclei, (2) many large amoeboid giant nuclei in the subcuticula of the trunk, (3) proboscis hooks failing to reach surface of proboscis wall, (4) trunk distinctly divided by constriction so as to form a definite collar and (5) bulbular proboscis together with the absence of (1) a true cephalic introvert organ and (2) a proboscis receptacle prohibit the assignment of the family group to any of the existing orders as currently constructed. It is suggested, therefore, that a new order be created for the reception of the members of the family APORORHYNCHIDAE. The name SPHENACANTHOCEPHALA is proposed for the new order.

SPHENACANTHOCEPHALA, NEW ORDER

METACANTHOCEPHALA:—Small, sub-conical forms with body separated into proboscis and trunk. Proboscis button-shaped or bulbar, with infolded anterior wall, incapable of being withdrawn into body, without typical hooks but with numerous fine spines. Trunk divided by constriction, producing anteriorly a collar for reception of base of proboscis. Proboscis receptacle absent. Longitudinal canals of lacunar system dorsal and ventral in position. Lemnisci long, with many giant nuclei. Subcuticula of trunk with many large giant nuclei. Ligament sac persistent. Cement glands of male eight in number. Body cavity large, continuous throughout entire length of body. Special nephridial organs absent. Embryos ellipsoidal, with three membranes. Parasitic about vent of passerine birds.

Type and only family: APORORHYNCHIDAE Shipley, 1899.

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Explanation of Figures

Unless otherwise indicated all figures are drawn to the same scale and were sketched with the aid of the camera lucida.

Abbreviations Used

A.F. atrial funnel
B. brain ganglion
B.C. bursa copulatrix
B.W. muscle fiber attaching to ligament sac
C. collar
.C.B. cavity of bursa
Cf. retractor-muscle ring fiber
C.G. cement gland
C.M. circular muscle
C.N. giant nucleus of body wall
Cs. body constriction
C.R. sphincter of proboscis
C.Sp. spine-like hooks on inner wall of collar
Cu. subcuticula
D.C. duct of cement gland
D.L. dorsal canal of lacunar system
D.R. dorsal ramus of ligament sac
E. extensor muscle of proboscis
Ej. ejaculatory duct
Ej.P. blind pouch of ejaculatory duct
E.M. everter muscle of bursa
E.S. entrance of accessory pouch into bursal cap
F.T. fibrous tissue supporting brain ganglion
G. genital pore
G.B. genital bulb

G.C. genital (bursal) cap
G.E. gelatinous-like capsule of ova
G.F. genital funnel (uterine bell)
G.P. genital papilla
G.T. retractor muscle of genital bulb
H.T. host tissue
I.C. inner wall of collar
I.P. infolded wall of proboscis
L. lemniscus
La. lacuna of subcuticula
La.L. lacuna of lemniscus
L.L. longitudinal muscle of lemniscus
L.M. longitudinal muscle of proboscis
L.N. giant nucleus of lemniscus
L.R. latero-radial muscle of proboscis
L.S. ligament sac
L.T. longitudinal muscle of trunk
M.R. muscular ring of proboscis
N. nucleus of muscle
O. ovum
O.F. ovarian fragment
P. proboscis
P.P. pit-like depression in proboscis wall
R. retractor muscle of proboscis
R.C. retractor muscle of bursa
R.M. reticular-like muscle of proboscis
R.P. retractor muscle of anterior wall of proboscis
S. selector cells of genital funnel
S.C. stellar-like muscle of proboscis
S.G. sphincter muscle of male genital pore
S.M. sphincter muscle of female genital pore
S.P. accessory (Saefftigen's) pouch
Sp. proboscis hooks
S.V. seminal vesicle
T. testis
T_1. anterior testis
T_2. posterior testis
Tr. trunk
U. uterus
Vd. vas deferens
Ve. vas efferens
V.L. ventral longitudinal canal of lacunar system
V.R. ventral ramus of ligament sac

THE COURSE OF INFECTION OF *PLASMODIUM LOPHURAE* IN CHICK EMBRYOS

R. Barclay McGhee[1]

INTRODUCTION

It is known that the age of the host exerts a decided influence on infections with *Plasmodium lophurae* in chickens (Coggeshall, 1938; W. H. and L. G. Taliaferro, 1940; Terzian, 1941), but no studies have been made of this parasite in chick embryos. Although infections have been established in duck embryos (Wolfson, 1940; Stauber and Van Dyke, 1945), no attempt has been made previously to follow the course of infection in individual embryos. In order to further determine the effect of age upon susceptibility and to make a detailed study of the course of infection, chick embryos were inoculated with erythrocytic stages of *P. lophurae* and daily studies made on infected individuals of various age groups.

MATERIALS AND METHODS

The strain of *P. lophurae* used in this study was derived from strain 12A carried in this laboratory through Rhode Island Red chicks. Both White Leghorn and Rhode Island Red chick embryos served as experimental hosts. Inoculations in embryos were made following the method of Eichorn (1940). Blood for serial passages was withdrawn from one of the large allantoic vessels (Beveridge and Burnet, 1946). As much as 0.4 cc of blood has been obtained in this fashion without resulting in the death of the embryo. The greatest amount of blood obtained from a single embryo was 0.75 cc. Inocula consisted of 3×10^7 parasites per embryo unless otherwise indicated.

Daily blood smears were made in the following manner: A large allantoic vein was located and the overlying shell marked with a series of short lines at right angles to the course of the vein. Succeeding lines were drilled daily. The drill was allowed to just penetrate the inner shell membrane, thus abrading the vein to the extent that sufficient blood for a smear could be drawn into a capillary pipette. If this procedure was carefully followed no hemorrhage resulted. The exposed area was sealed with celloidon and the egg was returned to the incubator.

Blood smears were stained with Giemsa after fixation with methyl alcohol. Semilogarithmic scales were used in graphs to accentuate the preliminary rise of infection and to indicate any minor relapses. Parasite counts during the course of infection were stated at the number per 10,000 red blood cells, with a 10 per cent probable error or less for values over 150 parasites per 10,000 red cells, of 15 per cent or less for those between 50 and 150, and of 20 per cent or less for those below 50 (Gingrich, 1932).

EXPERIMENTAL RESULTS

Three hundred twenty chick embryos 7 through 15 days of age, representing 15 passages, have been intravenously inoculated with erythrocytic stages of *P. lophurae*.

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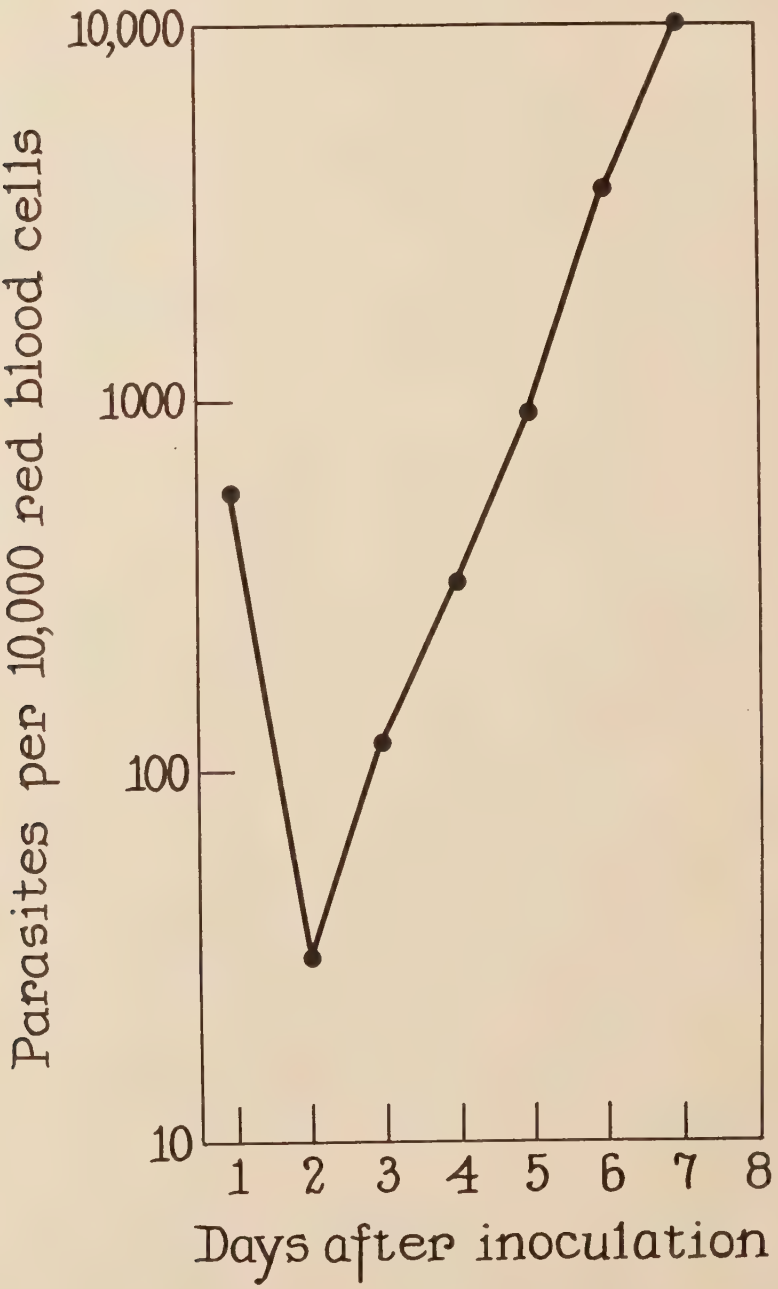
[1] From the Department of Animal and Plant Pathology, The Rockefeller Institute for Medical Research, Princeton, New Jersey.

Mortality rates resulting from trauma differed according to the age of the embryo at inoculation. Although only 5 seven-day embryos were injected none died from parasite introduction. The mortality rate for 107 ten day embryos was 35 per



Explanation of Figures

Fig. 1. Parasite counts of embryo 12 (1st passage) to show the preliminary drop in parasite numbers.

cent, but in 100 embryos inoculated at the close of the work, the rate dropped to 13 per cent. Two per cent of 108 embryos inoculated at 14 days died within 2 days. All embryos surviving beyond this time became infected.

The average time to death due to malaria varied in relation to the number of parasites introduced. Embryos died from infection as early as 4 days or survived as long as 10 days. Only two embryos, both of which had been inoculated at 15 days, survived hatching. Both died within one hour following emergence. In the initial and first passages, parasite numbers dropped in certain embryos on the first or second day. In embryo 12, for example, the parasitemia dropped from 400 on

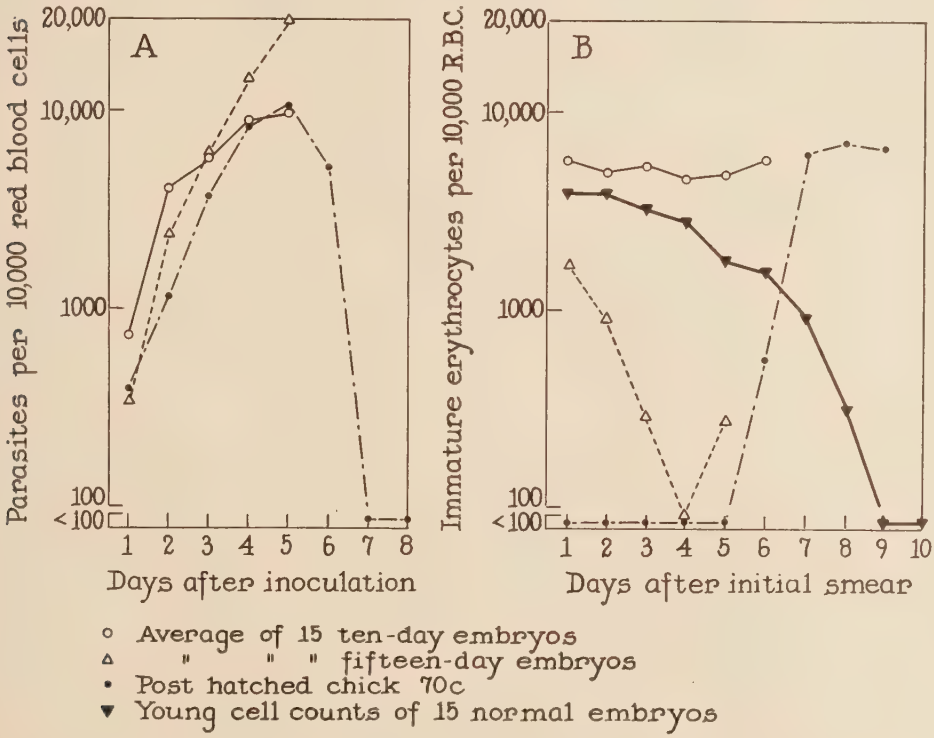


FIG. 2. A, The course of the parasitemia in a chick inoculated when 14 days old and in embryos inoculated at 10 and at 15 days of incubation with parasites from the 5th embryo passage; B, The changes in the proportions of immature erythrocytes in the same animals during the course of their infections and, for comparison, a curve showing the normal downward trend of the number of young red cells in uninfected embryos during the 11th to 21st days of incubation (obtained from normal embryos some of which were bled daily while others were sacrificed at various days).

the first day to 20 on the second, followed by a quick recovery and rapid rate of reproduction (Fig. 1). In succeeding passages, parasite numbers did not decline but increased at a rapid rate until the death of the embryo, whether inoculated at 10 or 15 days incubation. Parasitemias reaching 22,500 parasites per 10,000 red blood cells were recorded in embryos inoculated at 15 days incubation and 11,200 parasites per 10,000 red blood cells in embryos inoculated at 10 days. No crisis appeared. Infections were similar to *P. gallinaceum* infections in chick and duck embryos (McGhee, 1949) and progressed until the death of the host.

The rate of parasite reproduction was slightly greater in older embryos (Fig. 2A). Within age groups, however, parasite increases were uniform, the peak of parasitemia being dependent on the inoculum. For example, in group of 15 embryos each given 3×10^7 parasites the maximum and minimum per day throughout the life of the embryo differed but slightly from the mean parasite count (Fig. 3).

Although there was no great difference in the rate of parasite reproduction in

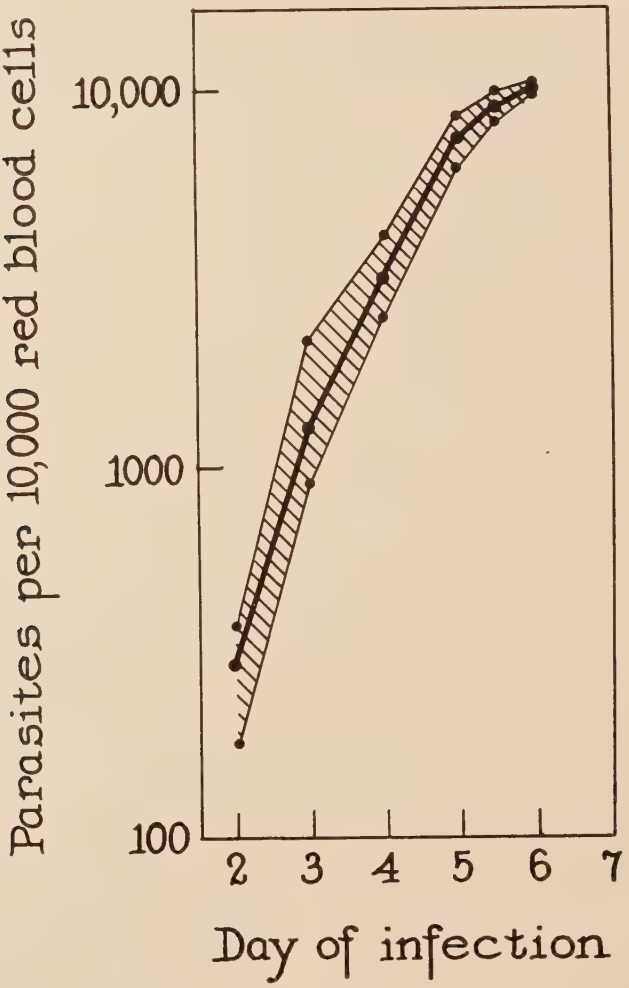


FIG. 3. The mean (heavy line) and range (shaded area) of 10 embryos inoculated at 10 days with 3×10^7 parasites.

embryos inoculated at various ages, the blood picture of the host was observed to vary with this factor. The blood of normal chick embryos of 10 days incubation has 38 per cent immature cells composed chiefly of polychromatophil erythroblasts, a few basophil erythroblasts and large lymphocytes (the lymphoid haemocytoblasts of Danchakoff, 1916). About 9 per cent of the blood cells were primitive erythroblasts. In the ensuing days the number of immature cells diminished until, at the 20th day, the picture was essentially that of a hatched chick (Fig. 2B).

In embryos infected at 10 days the young cell count remained high, increasing slightly just prior to death (Fig. 2B). Throughout the period of infection some immature definitive erythrocytes were infected, the number rising in one embryo to 56 per cent. Ninety-two per cent of the primitive erythroblasts were infected in certain embryos at the height of infection. Although as high as six parasites have been found in a single primitive erythroblast, only one parasite has been found segmenting. The parasites stained more deeply, appeared more dense, and often had large vacuoles in the cytoplasm. The high young cell count was not due to daily bleeding since uninfected embryos from which smears were made daily the blood picture was the same as that recorded for individuals bled on only one day. Young cell counts in embryos inoculated at 15 days were low initially and continued to drop in numbers until just prior to death (Fig. 2B). The number of primitive erythroblasts was too low for accurate counts.

DISCUSSION

P. lophurae infections in chick embryos were distinguished by a rapidly increasing parasitemia and the absence of any crisis. The greater susceptibility to infection further extends the findings of Coggeshall (1938), W. H. and L. G. Taliaferro (1940), and Terzian (1941) on the influence of host age upon susceptibility. It is of interest to note that the smallest inoculum produced a high, albeit a prolonged, infection invariably resulting in the death of the embryo. These results emphasize the lack of resistance in embryos and concur with the findings of Murphy (1914) and Grasset (1929).

P. lophurae has been considered a parasite which, to a great extent, invades only mature erythrocytes (Terzian, 1941). Infections in younger embryos indicated that cell age is an inefficient barrier to invasion, except possibly on the initial passage, and confirmed the observations of Stauber and Van Dyke (1945) who reported 76 per cent of the primitive erythroblasts in duck embryos infected with *P. lophurae*. The presence of parasites in these cells would seem to indicate an adaptation, but if an adaptation was present it was not in the nature of *Dauermodifikationen* since subinoculation into hatched chicks produced an infection typical for the parasite (Fig. 2A). It is more reasonable to assume that the primitive erythroblasts more nearly resembled the mature erythrocyte, and were utilized by the parasite in preference to the cells of the lower definitive erythrocytic series.

The difference in the per cent of young cells in embryos inoculated at various ages might account for the difference in reproduction rates. As seen in figure 2B the stimulus applied by infection caused the young cell count to remain high in 10 day embryos. In older embryos, there were sufficient mature erythrocytes to afford a greater selection of host cells without causing destruction to the extent of interposing a burden on the embryo blood system until just prior to death. It seems logical to assume, therefore, that although parasites are capable of infecting young cells, the chances of survival of merozoites in a medium composed largely of such young cells would be diminished.

The uniformity between infections in different individuals was quite different from that seen in post-hatched chicks, in which fluctuations in parasite curves are quite common. The uniformity in embryos perhaps reflected the more controlled conditions of movement, darkness and nutrition.

SUMMARY

P. lophurae infections in chick embryos were characterized by a rapid increase in parasite numbers, the absence of a crisis, and the death of the host. Infections increased more rapidly in older than in younger embryos, although the infections in any given age group were distinctly uniform. Following introduction in 10 day embryos the young red cell count remained high, in 15 day embryos it dropped until just before death. A high percentage of primitive erythroblasts and a certain proportion of immature definitive erythrocytes were parasitized.

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CYTOLOGICAL STUDY OF *RHOPALIAS MACRACANTHUS* CHANDLER, 1932, A TREMATODE FROM THE OPOSSUM, *DIDELPHIS VIRGINIANA**[1]

HONORICO CIORDIA

INTRODUCTION

Cytotaxonomy of the parasitic worms received momentum when Jones (1945) studied the relationship between chromosome number, morphology and ecology of 15 species of cyclophyllidean cestodes belonging to the families HYMENOLEPIDIDAE and DILEPIDIDAE. Britt (1947) made a cytological study of digenetic trematodes representing the families ALLOCREADIIDAE, CLINOSTOMATIDAE, LECITHODENDRIIDAE, CEPHALOGONIMIDAE, GORGODERIDAE, PLAGIORCHIIDAE, and RENIFERIDAE. Even if the work done in this field is relatively small, there have been some definite conclusions drawn by the above mentioned authors, and the importance of this type of study has become clearer. Jones pointed out that the diversity in the chromosome numbers among the species of DILEPIDIDAE runs parallel to the diverse morphology and the fact that their hosts have varied habits of feeding and nesting. Britt suggested, on the basis of cytological evidence, that the family ALLOCREADIIDAE should not be grouped in the same superfamily (PLAGIORCHIOIDEA) with PLAGIORCHIIDAE, and that the family LECITHODENDRIIDAE should be placed in the same superfamily (PLAGIORCHIOIDEA) with PLAGIORCHIIDAE and RENIFERIDAE.

The classification of parasitic worms is complicated and uncertain (Stunkard, 1947). It is artificial and has to be based upon the characteristics of the excretory systems, larval stages and host incidence before it can be of any value in taxonomic work. It is still of little use in establishing criteria to demonstrate phylogenetic relationships. When the cytology of parasitic worms has been studied, some of the mysteries surrounding their diversities in ecology and morphology may be clarified. This paper on the cytology of *Rhopalias macracanthus* Chandler, 1932, is intended to contribute to the desired knowledge.

MATERIALS AND METHODS

All the specimens were obtained from the small intestine of an opossum (*Didelphis virginiana*) and immediately rinsed in normal saline solution. Six were flattened under a cover glass during fixation for purposes of identification; the remaining specimens were fixed by Looss' shaking method. Carnoy 6:3:1 was used because of its versatility as a fixative for whole-mount preparation and because it could be followed by iron haematoxylin for cytological studies. The trematodes were left in the fixative overnight, then washed in 80 per cent ethanol, and stored in 70 per cent ethanol.

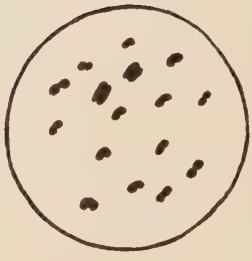
Received for publication, January 31, 1949.

* This work is part of a thesis submitted to the graduate faculty of the University of Tennessee in the partial fulfillment of the requirements for the degree of Master of Science. The author gratefully acknowledges his indebtedness to Dr. Arthur W. Jones, of the Department of Zoology and Entomology of that university, for his generous help, suggestions, and criticisms offered throughout the conduct of this investigation.

[1] Contribution from the Department of Zoology and Entomology, the University of Tennessee, Number 21.

1

1A



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4

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FIGS. 1-5

Material for sectioning was prepared by dehydrating through the various percentages of ethanol, clearing in chloroform and slowly infiltrating with paraffin. Sections were cut at 12 micra, since thinner sections may be cytologically untrustworthy.

Sections were stained with 0.5 per cent iron haemotxylin, differentiated with a saturated aqueous solution of picric acid, and mounted in neutral balsam. Whole preparations for identification purposes were stained with Reynold's Delafield-Cochineal overnight and differentiated in 70 per cent acid alcohol until pink in color; then differentiation was stopped with 70 per cent alkaline alcohol until slightly purple. Stained specimens were cleared in carbol-xylol and mounted in neutral balsam, care being taken not to permit air to come in contact with the dehydrated specimens.

Smear preparations of the gonads and the eggs were made after dissection under a wide field binocular microscope with the aid of steel needles. The specimens were treated with a 45 per cent solution of glacial acetic acid before being dissected. The preparations were stained with aceto-orcein. Better results were obained when the dissected organs were treated with iron alum, used as a mordant, for fifteen minutes and then stained with aceto-orcein. This was a modification of Godward's (1945) stain for algae. There was a certain degree of precipitation present, but the flakes formed were easily removed with the aid of a needle.

All drawings were made with the aid of a camera lucida and are reproduced at a magnification of 2700 X. Spacing of the chromosomes was necessary in some of the drawings for purpose of clarity.

OBSERVATIONS

Chromosomes were observed in the testes, ovaries, and eggs. The best mitotic sets were seen in the ovaries and the meiotic sets were studied in the testes and eggs. All phases of meiosis can be studied in the testes, a fact which corresponds with the observations made by Britt (1947) in his studies of the cytology of 35 digenetic trematodes. Oogenesis also seems to run parallel to his observations.

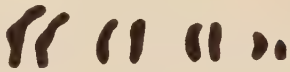
The chromosome number of *Rhopalias macracanthus* Chandler, 1932 was found to be eight haploid (Figures 5, 6, 7, 8, 9, 10 and 11), sixteen diploid (Figures 1, 2, and 3). There were no variations from this number in the fifteen specimens studied. The shortest chromosomes were about one micron long and the longest were 2.4 micra long. The mitotic chromosomes can be divided into three classes or groups. There are two long pairs, two medium pairs, and four short pairs (Figures 1A and 6A). The largest chromosomes probably have a median kinetochore, while the rest have subterminal kinetochores, although the small size of the chromosomes handicapped the study of this detail.

Description of Figures 1–5

(All figures were made with the aid of a camera lucida and are reproduced at a magnification of 2700 X).

1. Ovary, late prophase, $2n = 16$
1A. Idiogram of late prophase
2. Ovary, mitotic metaphase (spaced)
3. Testis, mitotic metaphase
4. Testis, anaphase
5. Smear preparation, ovum showing sperm

6



6A

7

8

9

9A

10

11

FIGS. 6-11

DISCUSSION

Although forty-seven species of digenetic trematodes have been studied cytologically (see Britt, 1947, for review of literature) species in the family RHOPALIADIDAE, as in many other families, have been completely neglected. *Rhopalias macracanthus,* a member of this family, was found to contain chromosome number (n = 8; 2n = 16) which lies within the range of haploid chromosomes numbers of 6, 7, 8, 9, 10, 11, and 14 occurring in the species of the families studied by other investigators. As was found in another group of hermaphroditic parasites, the cestodes, by Jones (1945), and in the digenetic trematodes by Britt (1947), there is no trace of polyploidy. Polyploidy is rare in hermaphroditic animals (see White, 1940, 1945, and Jones, 1944). It is thought not to occur in dioecious animals, perhaps because the sex mechanism and ratio would be upset by polyploidy (Muller, 1925). It is believed that bisexual organisms should exhibit polyploid series as exhibited by higher plants. In the case of the digenetic trematodes so far studied, the variety of chromosome number is probably not due to polyploidy, but to the gradual addition or loss of chromosomes—thus aneuploidy may have played a part in speciation in this group of trematodes.

SUMMARY

1. Fifteen specimens of *Rhopalias macracanthus* Chandler, 1932, belonging to the family RHOPALIADIDAE (TREMATODA, DIGENEA), have been studied with regard to chromosome number and morphology. The chromosome number was found to be eight haploid, sixteen diploid.

2. Techniques of collection, fixation, and staining are described. The trematodes from the opossum (*Didelphis virginiana*) were fixed in Carnoy, sectioned at 12 micra, and stained with 0.5 per cent iron haematoxylin. Smear preparations were not very successful.

3. The chromosome number of this organism was found to be within the range found by Britt (1947) in his studies of 35 digenetic trematodes, indicating that aneuploidy played a part in speciation of these trematodes.

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DESCRIPTION OF FIGURES 6–11

(All figures were made with the aid of a camera lucida and are reproduced at a magnification of 2700 X).

6. Testis, metaphase I
6A. Idiogram of metaphase I
7. Testis, metaphase I
8. Testis, first meiotic prometaphase, n = 8
9. Smear preparation of testis, first meiotic prometaphase
9A. Idiogram of Figure 9
10. Testis, metaphase II, n = 8
11. Testis, anaphase, II, one pole present

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MYOBIID MITES (ACARINA: MYOBIIDAE) FROM *CONDYLURA CRISTATA* (LINNAEUS) AND *NEUROTRICHUS GIBBSII* (BAIRD) (MAMMALIA: TALPIDAE)

E. W. Jameson, Jr.

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In this paper are described three species of myobiid mites, two of them as new; and for these species are described two new genera.

The first pair of legs is a useful generic character in myobiid mites, the number and shape of the segments, and their setae being rather constant within a genus. The position of setae on the segments helps to establish the identity of the segments in instances where coalescence has occurred. The tarsal claws on the first pair of legs are not always clearly visible, but those on the remaining legs are important characters of generic caliber. The shape of the penis, the nature of the dorsal setae, and the presence of sclerotized areas are all helpful in defining genera. The conspicuous marginal setae do not seem to be useful taxonomically. Previously (Jameson. 1948: 336) the setae about the anus were termed circumanal. Ewing (1938: 183), in his useful paper on this group, inferred that there may be a total of six submedian setae. Arbitrarily then, those setae behind submedians VI are considered circumanals.

Ewing (1938: 193) retained *Myobia brevihamata* Haller in its original genus, but the second pair of legs bear two tarsal claws, excluding this species from *Myobia*. Myobiid mites from the star-nosed mole, *Condylura cristata* (Linnaeus), are congeneric with but specifically distinct from *M. brevihamata*. Additional specimens from the shrew-mole, *Neurotrichus gibbsii* (Baird), are virtually identical with *M. brevihamata*. The following genus is erected to contain these two species.

EADIEA, new genus

Legs I (Fig. 4, E) of five segments; segments II and III with ventral clasping tubercles, that of segment III movable in a plane perpendicular to the axis of the leg; segment V with two curved claws. Legs II, III, and IV each with two tarsal claws. Coxae III and IV with dorsal setae not especially elongated. Some dorsal setae foliaceous. Penis slender, coiled in a single loop, directed cephalad. Capitulum (Fig. 4, D) as illustrated, with two pairs of setae dorsally; pores oval.

Genotype: *Eadiea condylurae*, n. sp.

Eadiea resembles *Radfordia* Ewing, 1938 in possessing two tarsal claws on legs II, and in having the first pair of legs of the same size. A comparison of the first pair of legs of *Eadiea* (Fig. 4, A and E) with those of *Radfordia ensifera* (Poppe, 1896), the genotype of *Radfordia*, (Fig. 4, B) shows that the two species are not congeneric. *Eadiea* differs from *Radfordia* in having legs III and IV each with two tarsal claws; *Radfordia* has but a single claw on each of these legs. The penis of *Radfordia* is slender, but not coiled.

Key to the species of the genus *Eadiea*.

A. Ventral setae of coxae II and III peglike and striated. Submedians II of female subequal to submedians I. . . . *brevihamata* (Haller, 1882).

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AA. Ventral setae of coxae II and III slender, not striated. Submedians II of female six to eight times as long as submedians I. . . . *condylurae,* n. sp.

Eadiea condylurae, new species.

Legs I (Fig. 4, E) as illustrated. Ventral setae on coxae II and III and IV slender, not striated. Leg II with tarsal claws of equal length, the posterior more slender. On legs III and IV the posterior claw is shorter and more slender.

Female (Fig. 1, A and D). Dorsal setae: Submedians I small, simple, slightly caudad from a line connecting laterals I, closer to their adjacent laterals than to each other; submedians II six to eight times as long as submedians I, slightly caudad from a line connecting laterals II, closer to their adjacent laterals than to each other, and overlapping the bases of submedians I, II; submedians III–VI subequal, about half as long as submedians II, each with sudden decrease in width slightly beyond the midpoint, each overlapping the base of the seta-adjacent caudally. Circumanals of four pairs: Circumanals I and II similar to submedians III–VI, latero-caudad from them, circumanals II laterad from the vulva; circumanals III twice as long as submedians I; circumanals IV subequal to submedians I; circumanals III and IV laterad from anus. Laterals I foliaceous, with five or six striations, extending beyond the bases of laterals II; laterals II simple, about twice as long as laterals I, latero-caudad from them; laterals III similar to laterals II, latero-caudad from them. Ventral setae: Three pairs of small setae between the bases of coxae II; a pair of small setae, similar to the first three pairs, between coxae III; a fifth and a sixth pair of setae directly caudad from the fourth pair, between coxae IV, five or six times as long as the fourth pair; a seventh pair slightly longer than the first four pairs, on the caudal margin.

Male (Fig. 1, B and C). Dorsal setae: Submedians I small, simple, slightly caudad from a line connecting laterals I, the distances between the setae being equal; submedians II subequal to submedians I, caudad from a line connecting laterals II. Genital orifice (Fig. 4, C) between coxae III surrounded by eight pairs of setae. Circumanals of one pair, slightly longer than submedians I. Laterals I foliaceous, with five or six striations, extending for about half their lengths beyond laterals II; laterals II simple, twice as long as laterals I, extending beyond the bases of laterals III; laterals III similar to laterals II. Ventral setae: Three pairs near coxae II, subequal to submedians I; a smaller fourth pair between the bases of coxae III, a fifth pair six to eight times as long as submedians I, meso-cephalad from coxae IV; the sixth pair subequal to submedians I, on a line connecting the caudal margins of coxae IV. The penis slender, in a single loop which may be compressed so that the penis is doubled back upon itself; penis is directed cephalad.

Type host: Condylura cristata (Linnaeus), star-nosed mole.

Type locality: Ithaca, Tompkins County, New York.

Types: Holotype female and allotype male; 2 April 1948; coll. W. R. Eadie; deposited in the U. S. National Museum.

Paratypes: Ten males and forty females with the same data as the types.

Eadiea brevihamata (Haller, 1882)

Leg I (Fig. 4, A) similar to that of *E. condylurae,* a point of difference being the mesal dorsal seta on segment III, it being striated in the present species. Ventral setae on coxae II and III peglike and striated. Tarsal claws on legs II equal; of those on legs III and IV, the posterior is shorter and more slender

Female (Fig. 2, B and C). Dorsal setae: Submedians I small, simple, slightly caudad from a line connecting laterals II, closer to their adjacent laterals than to each other; submedians II slightly longer than submedians I, caudad from a line connecting laterals II, closer to their adjacent laterals than to each other; submedians III–VI subequal, simple, four to five times as long as submedians II, submedians III on a line connecting laterals III; submedians III, IV and V overlapping the bases of IV, V, and VI respectively. Circumanals of three pairs, decreasing in size caudally: Circumanals I subequal to submedians VI, latero-caudad from them; circumanals II and III similar to circumanals I, laterad from the anus. Laterals I foliaceous and with five or six striations, extending for at least half their lengths beyond laterals II; laterals II simple, slender, extending beyond the bases of laterals III; laterals III similar to laterals II, latero-caudad from them. Ventral setae: Three pairs of small setae between the bases of coxae II; a fourth pair, slightly smaller than the first three pairs, between coxae III; a fifth and a sixth pair, five or six times as long as the fourth pair, near the bases of coxae IV; a seventh pair subequal to the first three pairs, on the caudal margin.

Male (Fig. 2, A and D). Dorsal setae: Submedians I small, simple, slightly caudad from a line connecting laterals I, closer to their adjacent laterals than to each other; submedians II slightly longer than submedians I, caudad from a line connecting laterals II. Genital orifice between coxae III, surrounded by six pairs of minute setae and two pairs of longer setae, subequal to submedians I. Laterals I foliaceous, with five or six striations, extending for at

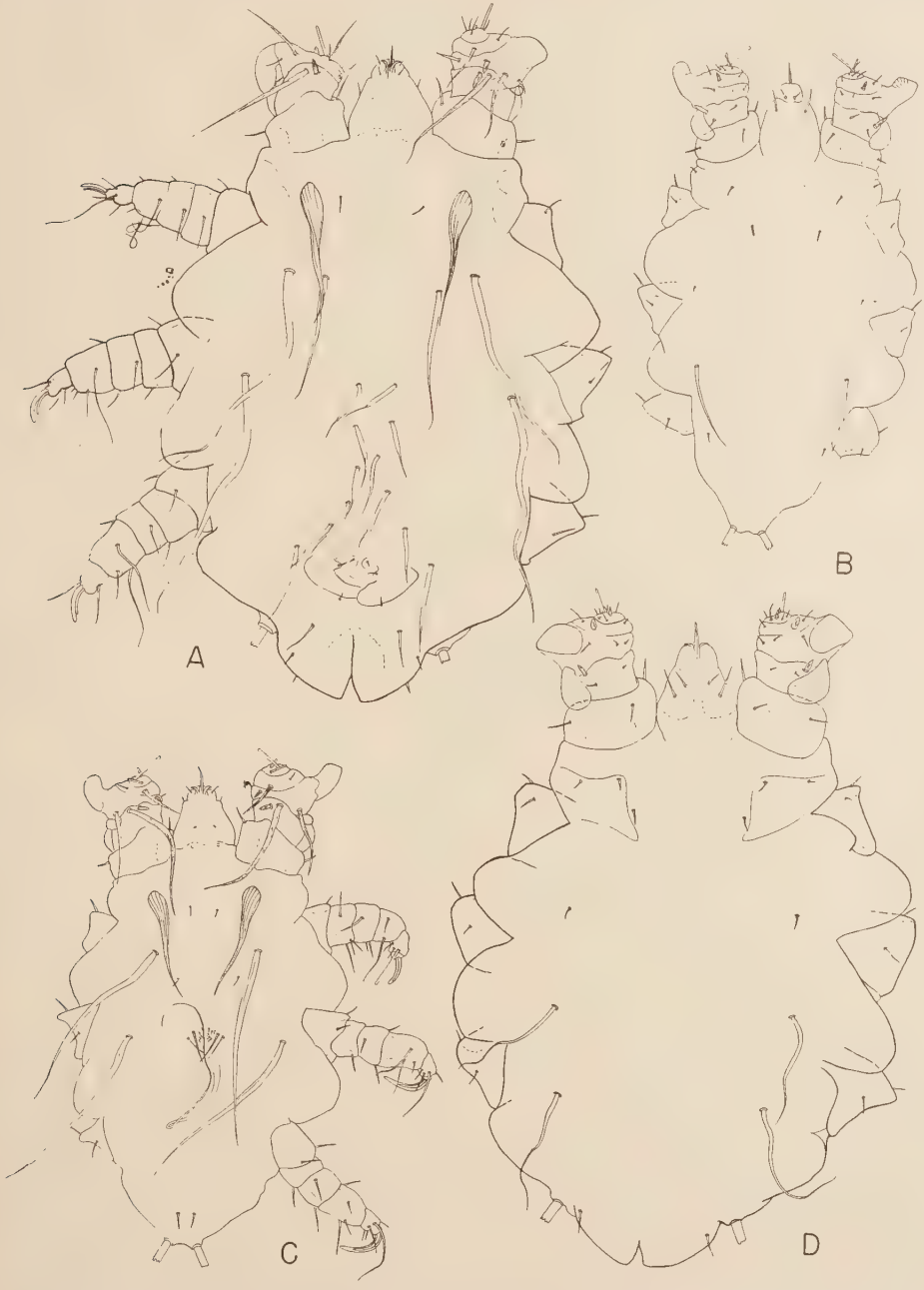

FIG. 1. *Eadiea condylurae,* new species. A, dorsal view of female; B, ventral view of male; C, dorsal view of male; D, ventral view of female.

least half their lengths beyond laterals II; laterals II simple, slender, twice as long as laterals I, extending beyond the bases of laterals III; laterals III similar to laterals II, latero-caudad from them. Ventral setae: Three pairs near the bases of coxae II, slightly longer than submedians I; a fourth pair between the bases of coxae III; a fifth and a sixth pair near the bases of coxae IV, the fifth pair five to six times as long as submedians I, the sixth pair subequal to

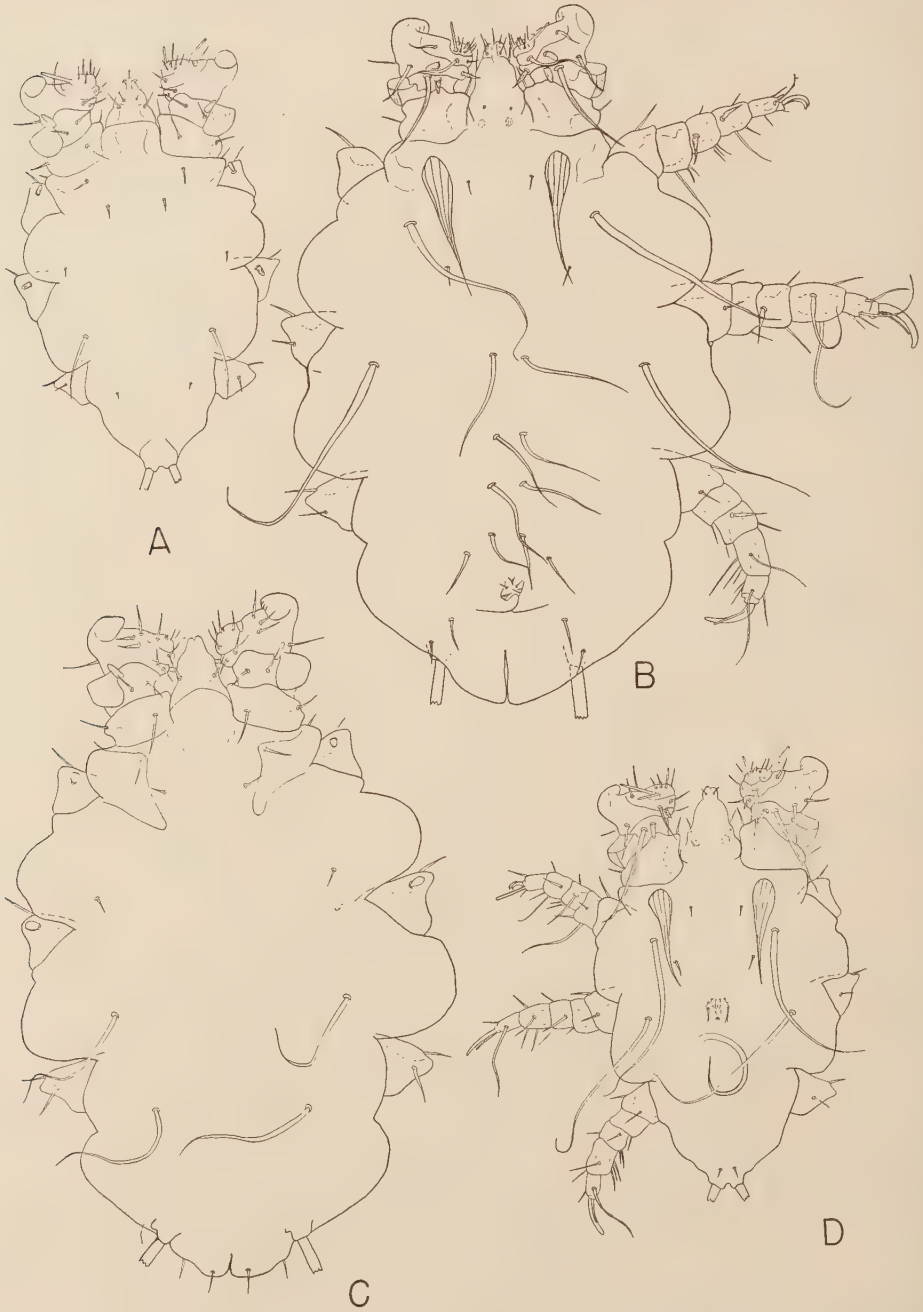

FIG. 2. *Eadiea brevihamata* (Haller, 1882). A, ventral view of male; B, dorsal view of female; C, ventral view of female; D, dorsal view of male.

the fourth pair, slightly shorter than submedians I. The penis slender, in a circular loop, directed cephalad.

Specimens collected: From *Neurotrichus gibbsii* (Baird); Plumas County, California; 12 November 1948, two males, one female; 28 December 1948, three males, three females.

The above specimens differ slightly from those collected from the type host (*Talpa europea*) in England, but with the scant material available a separation on the subspecific level is not justified. The illustrations and above description pertain to North American specimens of *E. brevihamata* from *Neurotrichus gibbsii*. No immature stages were collected. Nymphs of *Eadiea brevihamata* (from *Talpa europea*) have been described and figured by Radford (1936: 149).

The arrangement of the TALPIDAE into subfamilies seems artificial and the generic affinities are obscure (Jackson, 1915: 22; Simpson, 1945: 178). Assuming the evolution of the above species of *Eadiea* to have occurred simultaneously with that of their respective hosts, the host distribution of *Eadiea* argues for a closer relationship between *Talpa* and *Neurotrichus* than between either of these genera and *Condylura*.

Adults of *Eadiea* are bloodsuckers.

The shrew-mole is host to a second species of myobiid mite, which is not a blood sucker.

Eutalpacarus, new genus.

Legs I (Fig. 4, F) of four segments (segment IV consisting of IV and V coalesced); segments II and III with clasping tubercles ventrally, that of segment III movable in a plane perpendicular to the axis of the leg; segment II with a hyaline expansion mesad on the ventral side; segment IV with two curved claws. Legs II, III, and IV each with two tarsal claws. Coxae II and III with the dorsal setae not especially elongated. None of the dorsal setae foliaceous, but some may have bladder-like expansions. Some of the dorsal setae supported by sclerotizations. Penis slightly bowed, not coiled, directed caudad. Capitular pores elongate.

Genotype: Eutalpacarus peltatus, new species.

Eutalpacarus resembles most closely *Radfordia* and *Eadiea*. It is separable from *Radfordia* by the presence of two tarsal claws on legs III and IV. *Radfordia* has one tarsal claw on each of legs III and IV. *Eutalpacarus* differs from *Eadiea* in having the first pair of legs reduced to four segments, in possessing sclerotized plates supporting some of the dorsal setae, and in the absence of foliaceous setae. The penis of *Eutalpacarus* is bowed and directed caudad whereas that of *Eadiea* is once coiled and directed cephalad.

Eutalpacarus peltatus, new species.

Claws on legs II equal; those on III and IV unequal, the posterior claw being more slender and much shorter than the anterior.

Female (Fig. 3, B and C). Dorsal setae: Submedians I small, simple, on a line connecting laterals I, the distances between the adjacent setae about equal; submedians II subequal to submedians I, far caudad from laterals II; submedians III–V about five times as long as submedians I, each with a subbasal expansion, the tips truncate; submedians III cephalad from a line connecting laterals III; submedians VI simple, slightly longer than submedians I, directly caudad from submedians V. Circumanals of five pairs: Circumanals I and II cephalad from and adjacent to the vulva; circumanals I twice as long as submedians I; circumanals II about four times as long as submedians I, latero-caudad from circumanals I; circumanals III–V in two longitudinal rows on either side of the anus, decreasing in size caudad; circumanals III subequal to submedians I. Laterals I simple, extending to the bases of laterals II, each supported by a sclerotized extension arising between coxae I and II; laterals II simple, twice as long as laterals

FIG. 3. *Eutalpacarus peltatus,* new species. A, ventral view of male; B, dorsal view of female; C, ventral view of female; D, dorsal view of male.

I, each supported by a small, irregular, isolated sclerotization; laterals II extending slightly beyond the bases of lateral III; lateral III similar to lateral II, but each with a subbasal expansion. Ventral setae: Three pairs of small, simple setae between the bases of coxae II, all slightly longer than submedians I, two pairs of which are supported by two sclerotized mesal extensions; three pairs of small setae between coxae III; a seventh pair slightly cephalad of a line connecting coxae IV; and an eighth pair, twice as long as the seventh between coxae IV. Sclerotizations extend mesad from coxae III and IV. Dorsally, two small evaginations are situated caudad from submedians VI.

Male (Fig. 3, A and B). Dorsal setae: submedians I small, simple, slightly caudad from a line connecting laterals I, distances between adjacent setae approximately equal; submedians II subequal to submedians I, caudad from a line connecting laterals II; submedians III simple, three times as long as submedians I, slightly cephalad from a line connecting laterals III. Genital orifice between the bases of coxae III and IV, surrounded by five small setae, their ar-

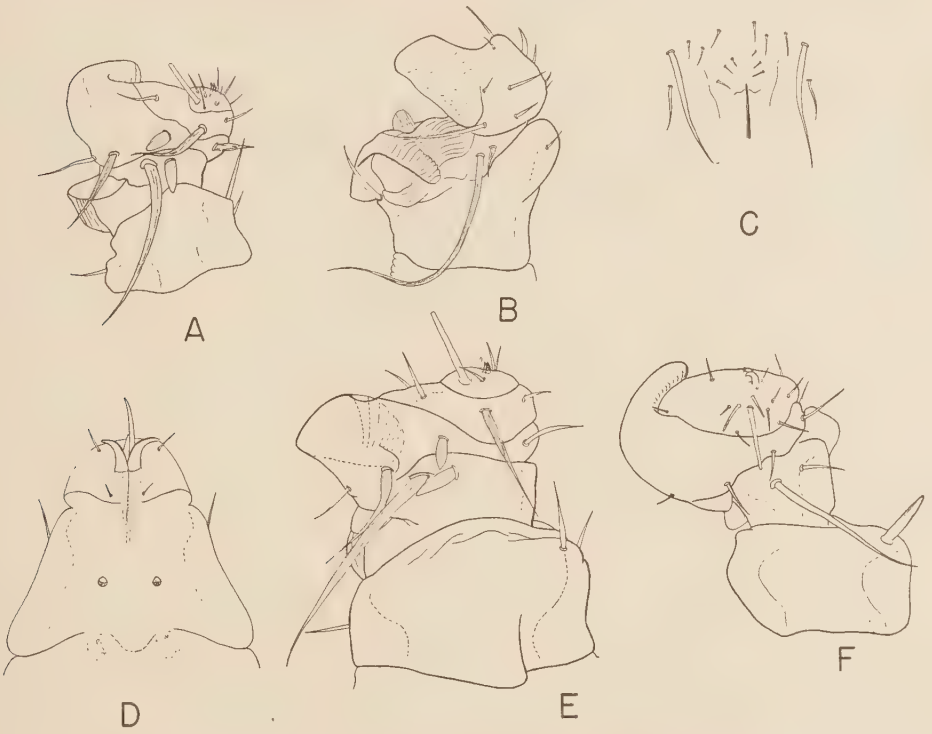

FIG. 4. A, leg I (left, dorsal) of female *Eadiea brevihamata* (Haller, 1882); B, leg I (left, dorsal) of female *Radfordia ensifera* (Poppe, 1896); C, genital orifice (male) of *Eadiea condylurae,* new species; D, capitulum (dorsal, female) of *Eadiea condylurae,* new species; E, leg I (left, dorsal) of female *Eadiea condylurae,* new species; F, leg I (left, dorsal) of female *Eutalpacarus peltatus,* new species.

rangement asymmetrical; the longest subequal to submedians I, apparently submedian IV, its mate latero-caudad from the genital orifice. Submedians V slightly longer than submedians IV, caudad from them; submedians VI two to three times as long as submedians V, each with a subbasal expansion. Circumanals of three pairs: Circumanals I subequal to submedians VI; circumanals II and III directly caudad from circumanals I, about half their length. Laterals I simple, extending beyond the bases of laterals II, each supported by a sclerotized extension arising between coxae I and II; laterals II simple, slender, two to two and a half times as long as laterals I, each supported by a sclerotized extension arising from the base of coxa II; laterals III slightly shorter than laterals II, each with a subbasal expansion. Ventral setae: Three pairs of small, simple setae, similar to the first three of the female; the fourth, fifth, and sixth pairs likewise similar to those ventral setae of the female; the seventh and eighth

pairs subequal, three times as long as submedians I, the seventh pair cephalad from a line connecting the cephalic margins of coxae IV, and the eighth pair between coxae IV. Mesal sclerotizations extend from the cephalic margins of coxae III, and terminate caudad from the fourth, fifth, and sixth pairs of ventral setae. The penis slender, slightly bowed, directed caudad.

Type host: Neurotrichus gibbsii (Baird), shrew-mole.

Type locality: Quincy, Plumas County, California.

Types: Holotype female and allotype male; 28 December 1948; coll. E. W. Jameson, Jr.; deposited in the U. S. National Museum.

Paratypes: One male and four females with the same data as the types; two males and two females from the type locality; 12 November 1948.

I wish to thank Dr. Charles D. Radford for specimens of *Eadiea brevihamata* from *Talpa europea.*

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A HUMAN OCULAR INFECTION BY *GNATHOSTOMA* IN CHINA

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Members of *Gnathostoma* parasitizing dogs, cats and pigs may become incidental parasites of man causing "creeping eruption" in the skin or subcutaneous tissue. Maplestone and Bhaduri's report (1937) gave a summary of 23 proved cases of human gnathostomiasis on record up to 1937, distributed as follows: 14 cases in Siam, 1 in the Malay States, 3 in Japanese in China, 1 in Japan and 4 in Bengal. Since then six additional cases have been noted (Maplestone and Sundar Row, 1939; Daensvang, 1939; Sen and Ghose, 1945; Mukerji and Bhaduri, 1945; Toumanoff and Le-Van-Phung, 1947; Toumanoff and Nguyen Van Huong, 1947). Galvao and Amaral (1939) may have reported a new case, but their publication is not available for examination.

In China dogs and cats commonly harbor *Gnathostoma spinigerum* (Morishita and Faust, 1925; Andrews, 1937; and Wu, 1937) and pigs *G. hispidum* (Chen, 1936), and human beings have been reported several times to be incidentally infected by the larval stage of this parasite. Tamura (1919) reported an infection from a Japanese woman just returning from a long sojourn in China and Morishita and Faust (1925) reported two cases, one from a Japanese who contracted the infection after one year's stay in China and another from a second Japanese also living in this country. Ikegami (1919) reported from Amoy, Fukien Province, a case of "creeping disease" which he regarded as caused by a species of *Echinorhynchus*. Morishita and Faust (1925) believed that from the author's description and figures this so-called *Echinorhynchus* was probably a young form of *Gnathostoma*. Samy (1918) reported from the Malay States an infection in a Chinese workman who had lived there for about a year.

Up to now all parasites, which have been identified to species, belong to *G. spinigerum* except one from Japan reported by Morishita (1924) who definitely identified the worm *G. hispidum* and two cases from India by Maplestone (1929) and Mukerji and Bhaduri (1945) who believed that their specimens were neither *G. spinigerum* nor *G. hispidum*. Maplestone found that the whole body of his specimen was covered by simple spines which excluded the possibility of *G. spinigerum* and the head armed with hooklets which were more complex than those found on *G. hispidum*. Mukerji and Bhaduri believed that their specimen belonged to the same species as Maplestone's.

The present report is based on a case from the Canton Central Hospital, Canton.* The patient, age 45, is a native of Canton, where he has lived most of the time, except for a short period during the Sino-Japanese War when he travelled in Szechuan, Hupeh and Hunan Provinces. When he came to the Eye Clinic for examination the gnathostome worm was found lying on the iris in the anterior chamber of the left eye and was successfully extracted. This is the third ocular gnathostomiasis on record, two others being recently reported by Mukerji and Bhaduri (1945) and Sen and Ghose (1945), both from Bengal, India.

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* The author is indebted to Dr. Chang E, the Ophthalmologist of the Canton Central Hospital, for the privilege of studying the specimen.

The worm is an immature form, cylindrical, 2.54 mm. long and 0.40 mm. wide, somewhat curved at the middle in the preserved state, with the anterior end truncated and the posterior conical. The cephalic end or head bulb is partly retracted into the cuticular collar of the body and is provided with four rows of recurved hooklets, each about 0.018 mm. long by 0.007 mm. wide. The root of the hooklet is simple, without notches or processes. The body is covered with annular striations which vary from 0.004 mm. to 0.014 mm. from one another, closer together at both anterior and posterior ends but farther apart in between. At higher magnifications some finer annular striations may be seen here and there. Many of these annulations are unquestionably due to contraction of the cuticula as a result of preservation. Imbedded partly in the striations are rows of spines, each about 7.5 μ long and 2.5 μ wide, which are easily seen on the forward part of the body, but become less conspicuous farther back and finally at the posterior end are visible only with difficulty at very high magnifications. The protruded part of the spine is short and very pointed while the part imbedded in the skin is longer, larger and rounded at the tip. Posteriad, the only portion visible under high magnifications is the protruded part. The spines are very crowded together from the anterior tip to approximately 0.60 mm. from it, varying from 1.5 μ to 6.0 μ apart, and then gradually many of them become farther spaced, some as much as 20 μ from one another.

Around the oesophagus there are two long cervical glands, 0.05 mm. in diameter and 0.714 and 0.643 mm. long respectively, which open to the anterior. In *G. spinigerum* four such glands have been reported, but in the present material only two are seen. The oesophagus is approximately 1.37 mm. long and is narrow at the anterior but gradually enlarges towards the posterior where it measures 0.328 mm. in diameter at the bulb. It is greatly twisted like an S-shape at the posterior half. The intestine is bent and extends to near the posterior tip where it connects with a short rectum 0.093 mm. long. Parts of a genital tube are seen between the twisted sections of the intestine at the posterior two-fifths of the body, but it is difficult to make out any details. The parasite is probably a male.

To identify a parasite in its larval stage is often a difficult task, particularly when one is dealing with a single specimen. Because of the nature of the cephalic hooklets and the extent of the body spines the present specimen is tentatively assigned to *G. hispidum*. Attention must be called to the fact that in the course of its development, hooklets, spines or other structures may likely undergo further changes.

In spite of the fact that the life cycle of *G. spinigerum* was recently elucidated by Prommas and Daengsvang (1933, 1936 and 1937), Africa, Rufuerzo and Garcia (1936a and 1936b), and Daengsvang and Tansurat (1938) with cyclops as first intermediate host and freshwater fish, eels and frogs as second intermediate hosts, the manner by which man becomes infected with either *G. spinigerum* or *G. hispidum* is still a disputable question. Some believe that human infection is derived from eating infected second intermediate hosts, such as fish or frogs, while others think it may have been caused by drinking water containing living infected cyclops. In the former case, which is the more probable means of transmission, the parasite, being unnatural to man, does not follow the ordinary route to become settled in the digestive tract but wanders in the peripheral tissues. In this particular case the patient has been very fond of raw fish delicacies which are rather popular among certain classes of population in the Canton area.

It is probably unnecessary to call attention to the fact that because *G. spinigerum* or *G. hispidum* is a rare parasite of man, unfamiliar to most of the clinicians in this country and because of the particular habit of the people which obviously favor such infections, gnathostomiasis in man may sometimes be wrongly diagnosed or easily overlooked.

SUMMARY

An immature specimen of *Gnathostoma hispidum*, the adult of which is normally a parasite of pigs, is found infecting the eye of a man from China. This constitutes the third ocular gnathostomiasis on record.

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RESEARCH NOTES

AN ATTEMPT TO INFECT MICE *IN UTERO* WITH *SCHISTOSOMA MANSONI*

While conducting studies on *Schistosoma mansoni* infections in mice the question arose as to whether or not the off-spring of mice exposed during the gestation period could be safely used for subsequent schistosome infections. Faust and Meleney (1924 Am. J. Hyg. Monogr. Ser. No. 3, pp. 58–59, 103–105) while studying the route of migration of *S. japonicum* found that the penetration glands of post-cercarial worms are recognizable through the gamma stage of the development. They concluded that even though the glands in this stage are considerably shrunken, they might still be of some aid in penetrating the hosts' tissues. Faust, Jones and Hoffman (1934 Puerto Rico J. Pub. Health and Trop. Med. 9: 228–282) also found that the penetration glands in *S. mansoni* persisted through the gamma stage. It is conceivable that during the first days of post-cercarial development in a pregnant animal some of the schistosomulae succeed in crossing the placental barrier and develop in the foetal circulation. Dr. M. Prates (personal communication) in Portugese East Africa, observed *S. mansoni* infection in an infant and concluded that it must have acquired the infection *in utero*.

Eight-week-old virgin female albino mice were used. They were caged with male mice with a ratio of 1 male to 3 females. The females were allowed to give birth to one normal litter before exposure to cercariae. This served two purposes: (1) sterile females were eliminated, (2) the number of days between conception and exposure could be determined more accurately. The gestation period for the first litter is 19 to 21 days, for subsequent litters is 20 to 21 days. A group of 14 pregnant mice were exposed percutaneously to 100–200 cercariae. These exposures were made 1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 14, 17, and 18 days after conception. Prior to parturition the females were isolated in separate cages. The parent females were sacrificed from 7 to 11 weeks after exposure and the number of worms in each mouse determined. The progeny were sacrificed when they were 6 to 8 weeks old. The perfusion technique for the recovery of worms (Yolles et al 1947 J. Parasitol., 33: 419–426) was used on all animals.

The parent females had all acquired the infection and the worm recovery ranged from 8 to 40 with an average of 25 worms per mouse. According to work done in this laboratory this is the expected worm recovery per mouse. The litters ranged in size from 4 to 10 with an average of 7 mice per litter. The off-spring did not exhibit any gross pathology attributable to schistosomiasis and none was found infected. These observations indicate that *in utero* infection of *S. mansoni* either does not occur or is very rare in mice exposed to 100–200 cercariae.—Donald V. Moore, Tamarath K. Yolles and Henry E. Meleney, *Department of Preventive Medicine, New York University College of Medicine.* This work was supported by a grant-in-aid from the Division of Research Grants and Fellowships, National Institute of Health.

LONGEVITY OF TROPICAL RAT MITES KEPT WITHOUT FOOD[1]

A colony of tropical rat mites, *Liponyssus bacoti,* was raised in a metal box as described by Scott, Stembridge and Sisley (1947, J. Parasit. 33: 138–141). Five days after the rat had been removed the mites which had climbed to the top of the box were removed by suction to rubber stoppered vials 25 mm. in diameter and 60 mm. high. The number of mites in each vial was only estimated since they were destined for experimental use and at this time there was no intention of studying longevity. One vial was not used, however, and when some of the mites were unexpectedly found to be alive at the end of a vacation period, the following history was summarized from the records and exact counts of the remaining mites begun.

The data are given in terms of the days after the last opportunity to feed. On the 5th day, i.e., on the day they were placed in the vial, from 200 to 300 were estimated to be present; on the 14th day about 100; on the 29th day about 50; and on the 34th day about 10. On the 52nd and 56th days 5 were counted; on the 59th and 61st days 2 were alive; on the 63rd day only 1 was alive, and all were dead on the 66th day. Plotting these figures on logarithmic paper shows that the numbers decreased at a constant rate as would be expected to occur as the result of chance losses. Most of our mites do not live so long and we are now trying to establish the optimum conditions for this purpose.—J. Allen Scott, *Department of Preventive Medicine and Public Health, University of Texas Medical School, Galveston, Texas.*

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POLYPLAX SERRATA (BRUMEISTER) AND *LINOGNATHUS SETOSUS* (OLFERS) RECORDED FROM THE HOUSE MOUSE, *MUS MUSCULUS* LINNAEUS IN TEXAS

A female specimen of *Polyplax serrata* (Brumeister) was taken from a *Mus musculus* Linnaeus January 30, 1947. This mouse was trapped from a building in the State Department of Health Laboratories, Austin, Texas, in a Sherman live trap. *Polyplax serrata* was orginally described from the house mouse, *Mus musculus,* in Europe. In the "Contributions Toward a Monograph to the Sucking Lice" by Dr. G. F. Ferris (1919–1923), Stanford University Press, this species of louse is recorded from *Mus musculus,* Fourth District, Scotland and the Shetland Islands by Evans under the name of *Polyplax affinis* (Brumeister). It is recorded by Fahrenholz from *Apodimus* (*Mus*) *sylvaticus* in Europe. The writer finds no reference in the literature of *Polyplax serrata* from *Mus musculus* in North America.

Ferris states that *Polyplax serrata* can be separated from the common domestic rat louse, *Polyplax spinulosa* (Brumeister) by the fact that the former is smaller (female 1.1 mm, male .6 mm.) and distinctly more slender. The sternal plate is more produced posteriorly and is more rounded. The sides of the tapering portion are concave instead of straight. The pleural plates differ consistently in having the ventral setae on the plates of the third segment much longer than the dorsal setae.

On February 18, 1947 a female specimen of *Linognathus setosus* (Olfers) was taken from the house mouse, *Mus musculus* in Lavaca County, Texas. Ferris states that *Linognathus setosus* is normally a parasite of the domestic dog and that it has been recorded from this host in many parts of the world. Other hosts listed by the same authority are: a European ferret recorded by Denny; a white fox in Alaska; captive fox in the United States; and from the coyote and rabbit recorded by Ewing.

The identification of both *Polyplax serrata* and *Linognathus setosus* was confirmed by Dr. G. F. Ferris.—George C. Menzies, *Bureau of Laboratories, Texas State Department of Health, Austin, Texas.*

A CULTURE MEDIUM FOR CHIGGERS (TROMBICULIDAE)

A number of culture media have been used at Duke University during the course of experiments on rearing the chiggers *Trombicula* (*Eutrombicula*) *alfreddugèsi* (Oudemans, 1910) and *Trombicula* (*Eutrombicula*) *splendens* Ewing, 1913. The media usually have been placed in widemouth, pint, glass, canning jars with tightly fitting screw caps. A mixture of plaster of Paris 90 parts by weight and activated charcoal 10 parts by weight is wet with distilled water to make a paste and poured into the culture jar to a depth of 2.5 cm. The hardened mixture then is kept moist with distilled water to maintain high humidity. (Wharton, 1946 Ecol. Monogr. 16: 151–184). The culture medium is spread over the set plaster-charcoal.

Trombiculids require a loose substrate into which they can burrow. Various types of soil as recommended by Jenkins, 1947 (Ann. Entom. Soc. Amer. 40: 56–68), cellulose wadding as used by Jaywickreme and Niles, 1947 (Nature 160: 578), peat moss as used in the U. S. Department of Agriculture laboratory at Orlando, Florida, humus from decaying logs, and vermiculite have been used. Cellulose wadding was unsatisfactory. Soil, humus, and peat moss have been used successfully, but have certain disadvantages. Among these are lack of uniformity, a variable content of organic material, a tendency to become covered with fungus, high density, and high cohesiveness. Vermiculite, a mica-like mineral used as a dilute or substitute for soil in greenhouses, has been found an excellent medium and lacks the disadvantages of the other materials used. In this work the regular or medium sized vermiculite (sold by Weiler and Harrington, 6908 59th. Drive, Maspeth, L. I., N. Y.) has been used. It is put over the plaster to a depth of about .5 cm. where it forms a porous bed through which all instars of the trombiculids can move freely. Vermiculite is light, soft, and not cohesive so that it can be rolled from side to side in the culture to expose the mites for observation without injuring them. Any mycelia that develop in the cultures can be broken up by rolling the vermiculite. Small insects, podurans, are regularly used to control fungus in the cultures, and they do well in vermiculite. Since vermiculite is sterile, inorganic, inert, and uniform, it permits better control of cultures than media previously used.

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